An economic, environmental and ethical assessment of meat production and consumption in South Africa

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Thesis presented in fulfilment of the requirements for the degree of Master of Environmental Management in the Faculty of Economics and Management Sciences at Stellenbosch University

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December 2020

DECLARATION

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ABSTRACT

The world is experiencing an explosive increase in human population, which means the demand for food and other products is also increasing. This increase in demand places the world's natural resources and environment under ever increasing pressure, and there is no end in sight.

It has been established that the livestock industry contributes immensely to global warming due to the greenhouse gasses it emits. Moreover, the industry consumes large quantities of fresh water, arable land and food sources to meet the growing demand for animal protein. The resources necessary for the production of meat could have been used to aid the world's starving population, which makes this industry and the human consumption of meat unethical. When viewing the consumption of meat from a philosophical point of view, it is also unethical for humans to dictate another sentient being's existence.

The author emphasises that the livestock industry should not end overnight as millions will lose their jobs across the world, but a gradual decrease in meat consumption is a topic worth discussing. Governments should employ policies to hold consumers and producers responsible for the external costs associated with the production and consumption of meat, which in turn will lead to an increase in price and thus a decrease in demand. Awareness campaigns should be launched to educate the public on the industry's negative impacts, as well as alternative food sources that could supply the same or even a better quality of protein at a fraction of the cost to the environment and their wallets. The negative stigma with regard to humans consuming insects should be discarded as it is an alternative to meat and is worth exploring.

The lifestyle of the world's current human population needs a serious new design as it is not sustainable.

OPSOMMING

Die wêreld ervaar tans ‘n enorme toename in sy menslike bevolking. Dit beteken dat die aanvraag na kos en ander produkte ook toeneem. Die toename in aanvraag beteken dat die wêreld se natuurlike hulpbronne en omgewing onder geweldige toename en druk geplaas word, waaraan daar geen einde in sig is nie.

Daar is reeds bewys dat die veenywerheid grootliks bydra tot aardverwarming weens al die kweekhuisgasse wat dit vrystel. Dié nywerheid verbruik groot hoevelhede varswater, bewerkbare grond en voedselbronne om die mensdom se aanvraag na vleis te bevredig. Die hulpbronne wat gebruik word om die mensdom se aanvraag na vleis te bevredig, kon gebruik word om die wêreld se mense wat in hongersnoodverkeers te voed. Om dié rede maak dit die veenywerheid en die verbruik van diervleis deur mense oneties. Indien die verbruik van diervleis deur die mens uit ‘n filosofiese oogpunt bekyk word, is dit ook oneties om te glo dat iemand ‘n lewende wese se leefwyse kan beheer.

Die skrywer benadruk die feit dat die veenywerheid nie oornag tot ‘n einde kan kom nie aangesien miljoene mense van dié nywerheid afhanklik is. Daar moet eerder ‘n omvattende bespreking oor ‘n afname in vleisverbruik plaasvind. Die regering moet ‘n beleid instel om vleisverbruikers en produsente verantwoordelik te hou vir die eksterne impakte wat die produksie en verbruik van vleis veroorsaak. Die beleid sal veroorsaak dat die prys van vleisprodukte toeneem wat ‘n afname in verbruik en gevolglik ook produksie tot gevolg sal hê. Bewusmakingsveldtogte moet geïnisieer word om die publiek op te voed oor die negatiewe impakte van die veenywerheid, asook oor alternatiewe voedselbronne wat mense kan gebruik om dieselfde/beter kwaliteit proteïene in te neem wat beter is vir die omgewing en vir die verbruiker geld sal spaar. Die gedagte dat die inname van insekte deur die mens afkeurenswaardig is, moet in die kiem gesmoor word aangesien die verbruik van insekte ‘n baie goeie alternatief vir proteïene is.

Dit kom daarop neer dat die leefstyl van die wêreld se mense aansienlik aangepas moet word aangesien die huidige een nie volhoubaar is nie.

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Homo sapiens consider themselves the conquerors of the universe. There is this view that people are divorced from nature and that the earth – for that matter the rest of the galaxy – may be exploited for the benefit of man. The alternative hypothesis presented is one where nature, inclusive of man, animal and plant-life, is the centre and none is more important than the other. As Charlie Chaplin said in *The Great Dictator*: "In this world there is room for everyone and the good earth is rich. It can provide for everyone. The way of life can be free and beautiful…"

However, as the global human population increases, so does the demand and desire for goods and services (Abbasi, 2016). One of those goods is food. It has been found that as the income level of a population increases, so does the use of animal protein (Abbasi, 2016). As a country evolves economically, its demand for livestock products increases rapidly. This trend is observed in developing countries such as South Africa and is expected to increase as the income per capita increases. Before the Haber-Bosch process, our production rate of animal products was restricted by the natural sources of fixed nitrogen provided by bacteria and lightning. The amount of livestock that could have been supported by the environment was thus kept in check. However, through technological advances and the evolution of farming techniques, humans are now capable of producing a once limited nutrient to stimulate crop growth and thus support the world's ever growing demand for food.

The livestock industry plays a significant role in South Africa's economy, not only in producing goods but also by creating employment opportunities. Many people depend on the industry to support their lives and families. The people who are dependent on the industry are the people who raise and sell the livestock, feed producers and retailers, cage manufacturers, chemists developing different chemical agents, butchers, packaging and transport companies, veterinarians, etc. It is easy to realize that the livestock industry has millions of dependants whose interests vary from making another million Rand to just feeding their family.

There are many opinions concerning whether breeding and raising animals purely for human consumption is morally acceptable. Apart from the proven detrimental environmental impacts of the livestock industry, one must also take a more philosophical approach to view the industry as a whole. Some people would agree with the utilitarian viewpoint put forward by Peter Singer. He believes that "The interests of every being affected by an action are to be taken into account and given the same weight as the like interests of any other being" (Regan, 1987). Is it morally acceptable for humans to mistreat sentient beings in a way that prematurely takes away the only thing valuable to them? Life. Many look at nature through an anthropocentric view and place their human interests above the interests of everything else. Most people such as William Baxter will only protect some natural good if they can obtain some economic benefit from it. As soon as it is not profitable to protect anymore, they would no longer invest more time or effort in protecting that natural good. This concept is known as shallow ecology. It is thus a theory that only sees the instrumental value of nature – meaning the value comes directly from the use of that specific natural good (Naess, 1973).

The opposite of shallow ecology is known as deep ecology and was first introduced by Arne Naess in 1973 (Naess, 1973). Deep ecology has two ultimate norms, self-realization and biocentric egalitarianism. Joanna Macy once said: "It would not occur to me… to exhort you to refrain from cutting off your leg. That wouldn't occur to me or to you because your leg is part of you. Well, so are the trees in the Amazon Basin; they are our external lungs. We are gradually discovering that we are the world." (Miller, 1999) In essence that is what deep ecology is about. Humans must realize that the other ±8.4 million species on earth have as much intrinsic value and right to live as humans. It is acceptable when humans take something from nature for their survival, with the emphasis on survival. However it must be taken with gratitude and not as if it is their right. Humans must recognize nature's intrinsic value and see it as a gift to them and in return treat it with the proper respect and care.

Although a sudden shift to a plant-based diet would have major global economic impacts on all the people and industries involved in the livestock industry, one must discount these immediate negatives against the morality of protecting animals from suffering and in the process saving the planet and mankind itself.

The debate around the production and consumption of animal products by humans requires a transdisciplinary analysis to fully grasp and understand this complex topic. Only then will it be possible to consider views from both parties (meat eaters and non-meat eaters) and attempt to resolve this debate.

The aim of this study is to synthesise and expand on existing data and findings and to evaluate the impact of the livestock industry on the environment. Moreover, this study will explore alternative protein sources, and explore the ethics behind raising livestock purely to satisfy human desires. A short survey was also conducted to better understand the general public's basic perception of the livestock industry.

Chapter 2 will examine the economic impact of South Africa's livestock industry. Chapter 3 investigates the environmental and social impacts of the livestock industry. Chapter 4 will apply an ethical and philosophical approach to the exploitation of sentient beings for human satisfaction. Chapter 5 explores alternative protein sources available for human consumption. Lastly, Chapter 6 will discuss the results of the public survey that was conducted to obtain a better understanding of the general public's perception regarding the livestock industry.

Chapter 2: The economics of South Africa's livestock industry.

2.1 Introduction

South Africa's agricultural economy consists of two role players, the well-developed commercial farming industry and the smaller-scale communal farming industry (usually located in rural areas). Although the growth value added (GVA) of agriculture to the growth domestic product (GDP) is relatively small, it is an important role player in providing employment opportunities, especially for South Africa's less skilled work force. The industry plays an important role in providing food security and basic needs to many and offers various economic and social attributes to South Africa (Meissner et al., 2013). Agriculture (including Forestry and Fishing) contributed 16.6% to GDP in 1951. In 2015 it only contributed 2.4% of which Agriculture proper represented 2.1%, Forestry 0.2% and Fishing 0.1%. (South African Survey, 2017). Still the employment in the agricultural sector stood at 5.3% in 2016 (South African Survey, 2017, p.252). Because of the linkages with the other sectors in the economy it is an important component of that part which contributes 14% of South Africa's GDP (Goldblatt, 2010). It was found that for every 1% that the agricultural sector contributes to the GDP, the total GDP of South Africa grows by 2% due to the interconnectedness of other sectors within the economy (Meissner *et al.,* 2013). The agricultural sector makes a vast contribution to job creation, as it is South Africa's second largest job provider (DAFF, 2006).

South Africa has undergone significant social and economic change since the abolishment of the apartheid regime 24 years ago. Democracy led to important structural transformations, which have resulted in an open, market-orientated economy. The change in government and subsequent policies aimed to terminate government's control of the agricultural sector, increase the life quality of farm labourers and address land equalities (Goldblatt, 2010). Generous subsidies and support from the State have ceased in the past 24 years, forcing South African farmers to become more efficient.

In 2008, South Africa became a net importer of food in terms of volume for the first time. Some may see this as an undesirable situation if they believe that national food security needs national production to meet demand. This also points to how important the livestock industry

is for food security. Livestock has always been an important part of agriculture, for subsistence and commercial purposes.

2.2. Contribution to GDP and trade

The gross value of livestock production in South Africa was estimated to average around R93,282,636, 000 between the years of 2011 and 2016 (DAFF, 2017a). When all the industries that are linked to livestock production (farm equipment, livestock feedcrop, pesticides, fertilisers, etc.) are brought into the equation, the contribution of the livestock industry to South Africa's GDP is very substantial.

The importing and exporting of livestock products in South Africa are usually a response to an excess or deficit of the production of that specific product, while wool, mohair and ostrich products are specifically aimed at the export trade (Meissner et al., 2013). The trade of meat products in South Africa is thriving. It is estimated that 39 000 tons of beef valued at R2 billion was exported during 2016 (DAFF, 2017b) with Asia and other African countries being the major importers. Although South Africa is exporting beef, it also imported some 19 000 tons of beef valued at R634 million from mainly African countries during 2016 (DAFF, 2017b). During the period of 2007 to 2016 South Africa's mutton import quantity decreased from about 27,550 tons in 2007 to around 9,500 tons in 2016 (DAFF, 2017c). During the same period, South Africa's mutton exports fluctuated between 400 to 1,500 tons, excluding 2010 and 2011 which experienced an increase to 4,100 and 10,000 tons respectively. South Africa is thus a net importer of mutton (DAFF, 2017c). Brazil was the main exporter of white meat to South Africa and provided the country with 348,155 tons of white meat (61.5%) in 2018, making the South African livestock sector a net importer of white meat (SAPA, 2019). The importation and exportation of egg and dairy products are dependent on the deficits during a particular time (SAPA, 2010; Milk SA, 2011). The value of various livestock products being exported or imported through the Southern African Customs Union (SACU) is displayed in Table 2.1 below (DAFF, 2017a).

Table 2.1 - Value of the Southern African Customs Union (SACU) imports and exports of agricultural products. Note the year 2016 contains preliminary values (DAFF, 2017a).

	2011	2012	2013	2014	2015	2016
	R1 000					
EXPORTS						
Wool	2 111 737	2 393 617	2 937 507	2 841 138	3 285 783	3 998 610
Raw skins of sheep and lambs	585 972	549 669	1 664 768	826 398	816 154	813 179
Other meat and edible meat offal	148 057	37 953	56 461	88 432	225 511	1 283 905
Raw hides and skins of bovine	186 930	288 860	535 765	577 964	613 033	381 353
IMPORTS						
Meat and offal of poultry	2 734 665	3 522 883	3 894 737	4 062 084	4 653 292	5 463 399
Meat of sheep and goats	560 833	471 601	405 685	313 481	321 294	284 987
Preparations used in livestock feeds	919 252	1 113 324	1 166 395	1 441 868	1 730 741	1 763 816
Hides and skins of bovine	47 601	48 777	103 423	148 221	138 299	101 358
Milk and cream	216 060	362 919	266 234	429 494	390 109	347 041

2.3 Production status of the livestock industry

Livestock production is found throughout South Africa. The livestock numbers, species and breeds are all dependent on the environment and the type of production systems occurring in the specific area (Meissner et al., 2013). Different production systems are practiced in South Africa – they include commercial, small-scale and communal ownership. Intensive farming systems are generally found in close proximity to metropolitans and feed suppliers (Meissner et al., 2013). It is estimated that South Africa is home to more or less 38,500 commercial farms and two million small-scale farmers farm with livestock. The amount of ruminant animals is displayed in Table 2.2 and the amount of non-ruminant animals is displayed in Table 2.3 (Meissner *et al.,* 2013).

The highest numbers of cattle, sheep and goats are in the Eastern Cape (refer to Table 2.2). The second highest number of beef cattle is found in KwaZulu-Natal with the Northern Cape having the second highest number of sheep. It was found that small-scale sectors possess 41% of the beef cattle, 12% of the sheep and 67% of the goats in South Africa. Limpopo and the Northern Cape are the two main provinces in which game farming is practiced. Commercially farmed pigs occur mainly in the Western Cape, North West Province and KwaZulu-Natal. About half of the small-scale sector's pigs are family owned in the Eastern Cape (refer to Table 2.3). Most of the country's 113 million broilers and a large amount of the

eggs are produced in the North West, Limpopo/Mpumalanga and the Western/Northern Cape. Ostrich farms are limited to the Western and Eastern Cape.

Table 2.2 - Estimated ruminant livestock numbers in South Africa (in thousands) (Meissner *et al.*, 2013).

Province	Beef cattle		Dairy[a] cattle	Sheep[b]		Meat goats[c]		Game[d]
	Comm.[e]	Other		Comm.	Other	Comm.	Other	
Western Cape	219	232	323	2 380	336	62	152	34
Northern Cape	603	208	13	5 361	758	144	355	671
Eastern Cape	1 531	1 272	348	6 410	906	643	1 588	341
KwaZulu-Natal	1 409	1 116	268	676	95	227	561	117
Free Sate	1 232	911	198	4 271	604	67	165	158
Mpumalanga	868	603	60	1 534	217	25	61	273
Limpopo	650	433	12	226	31	349	861	1 109
Gauteng	321	245	44	91	13	11	27	90
North West	1 035	713	102	612	86	202	498	198
Total	7 868	5 733	1 368	21 561	3 046	1 730	4 268	2 991
National Total	13 601		1 368	24 607		5 998		2 991

Table 2.3 - Estimated non-ruminant livestock numbers in South Africa and producers/owners (in thousands) (Meissner *et al.*, 2013).

Province	Pigs		Broilers		Layers		Ostriches[c]
	Comm.	Other[i]	Comm.	Breeders	Comm.	Breeders	Comm.
Western Cape[a]	157	10	21 793	1 419	5 192	59	960
Northern Cape[a]	20	1.6					
Eastern Cape	46	62	6 850	448	910	10	544
KwaZulu-Natal	163	10	16 309	1 061	3 670	42	
Free Sate	88	5.6	5 658	365	4 672	53	
Mpumalanga[b]	137	8.9	23 880	1 557	7 830	32	
Limpopo[b]	114	7.5					
Gauteng	111	7.2	5 658	365	6 596	75	
North West	174	11	25 713	1 674	2 584	29	
Rest of SA							96
Total	1 010	124	105 861	6 889	31 454	300	1 600
National Total	1 134		112 750		31 754		1 600

i) Other include family owned livestock.

The Food and Agricultural Organization (2009) predicted that the global livestock meat demand would increase to almost double of that today by the year 2050 driving an increase in production. This increase will be most predominant in developing and transition countries where wealth is expected to increase. Livestock products in South Africa have increased between 1995 to 2016 in relation to field crops and horticulture (refer to Table 2.4). During the 10 years between 1995 and 2005, the gross value of these three products was more or less the same. During this period the gross value of livestock products comprised 42% but increased to 47% during the years thereafter (Meissner et al., 2013). The absolute and relative

increase of gross value of livestock products are due to positive export conditions and an increase in demand (DAFF, 2010).

Table 2.4 – Gross value of agricultural production from 1995 – 2016 (Agricultural Statistics, 2017).

Sector	R million and % of total							
	1995/2000		2001/2005		2006/2010		2010/2016	
Field Crops	13 968	33%	21 303	31%	29 790	28%	51 081	26%
Horticulture	10 637	25%	18 344	27%	26 121	25%	52 293	27%
Livestock Products	17 744	42%	28 395	42%	50 586	47%	93 283	47%
Index relative to 1995/2000 as base period								
Field Crops	100		153		213		366	
Horticulture	100		172		246		492	
Livestock Products	100		160		285		526	

Table 2.5 provides the gross value of various livestock products from 2010 to 2016. The production of white meat has increased as a result of demand and the higher price per unit. South Africa's gross value of red meat increased due to unit price increases although the volume has also increased, but not to the same degree as white meat. Increase in value terms for red meat is more, but white meat is higher in absolute terms.

Table 2.5 – Gross value of various livestock products from 2010-2016 (Agricultural Statistics, 2017).

Year	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016
	R1 000					
Wool	1 607 481	2 087 639	2 435 839	2 740 676	2 774 343	3 361 218
Mohair	216 730	227 855	285 540	408 145	371 984	413 524
Karakul pelts	8 141	8 818	12 581	17 103	16 771	19 373
Ostrich feathers and products	398 868	295 345	276 255	341672	432 814	529 802
Fowls slaughtered	25 289 325	26 289 539	29 171 087	33 071 802	37 225 273	38 611 193
Eggs	6 999 700	7 734 494	8 400 652	8 882 997	9 438 719	10 170 589
Cattle and calves slaughtered	16 146 715	19 297 479	20 495 591	22 717 904	26 792 372	30 630 433
Sheep and goats slaughtered	3 987 079	4 526 435	4 648 444	5 407 051	6 626 134	6 567 869
Pigs slaughtered	3 003 295	3 531 255	3 713 738	4 264 911	4 976 775	5 252 968
Fresh milk	8 804 711	9 836 254	11 131 161	12 708 386	14 994 234	14 101 466
Other livestock products	4 723 501	5 323 219	5 588 080	6 060 993	6 192 626	7 070 847
Total	71 185 546	79 158 332	86 158 968	96 621 640	109 842 045	116 729 282

Table 2.6 - Demand for various meats during the period 2000/1 to 2016, in 1000 tons and per capita, kg/year (DAFF, 2017a).

Meat	2000/1		20002/3		2004/5		2006/7		2008/9		2010/11		2012/13		2014/15		2016	
	10^3t	/cap	10^3t	/cap	10^3t	/cap	10^3t	/cap	10^3t	/cap	10^3t	/cap	10^3t	/cap	10^3t	/cap	10^3t	/cap
Beef and veal	555	12.3	644	14.0	723	15.5	861	18.2	815	16.7	879	17.6	910	17.4	1023	19	1170	19.5
Pork	114	2.6	140	3.2	182	3.9	208	4.4	202	4.1	231	4.6	245	4.7	254	4.7	263	4.8
Sheep and goats	159	3.5	146	3.2	148	3.2	186	3.9	180	3.7	155	3.1	171	3.3	193	3.6	190	3.5
Total red meat	828	18.4	930	20.4	1054	22.6	1255	26.5	1197	24.5	1266	25.3	1325	25.3	1470	27.2	1525	27.7
White meat	938	21.5	1032	22.7	1204	25.9	1470	31.0	1551	31.9	1987	39.7	2061	39.4	2076	39.4	2200	40

Table 2.7 provides information of the composition of South African consumers' food baskets during the period of 2005 to 2010. Based on weight, livestock meat contributes 13% of the average South African consumer's food intake. The largest contributor is grain at 33%, which is mainly based on maize meal and bread. Vegetables also form a significant amount at 19% (Meissner *et al.,* 2013).

Table 2.7 – Weight, kg/year and proportional (%) contribution of field crops, horticulture and livestock products to the food basket of the consumer for the period 2005 to 2010. (Meissner *et al.*, 2013).

Grains	Maize	Wheat	Sorghum	Barley	Oats	Total	% of total
	78.8	49.1	2.09	4.90	0.80	136	33.4
Vegetables	Potatoes	Other					
	32.7	44.5				77.2	19.0
Fruit	Deciduous & subtropical	Citrus					
	28.7	10.9				39.6	9.7
Beans & nuts	Sunflower oil	Dry beans	Ground nuts				
	5.49	2.88	1.13			9.50	2.3
Livestock meat[(b)]	Beef/veal	Pork	Mutton/ lamb & goat	White meat			
	16.8	4.14	3.58	29.9		54.4	13.4
Livestock other	Eggs	Butter	Cheese	Condensed/ powder milk	Milk		
	8.17	0.30[(c)]	0.80[(c)]	8.10[(c)]	39.4	56.8	14.0
Livestock totals						111	27.3
Sugar						33.0	8.1
Grand TOTAL						407	100

(a) The contribution to the food basket is based on the demand for the various products opposed to their consumption as the figures are based on what was produced and the difference between imports and exports. The figures did not take wastage and preparation losses into consideration, (b) includes edible offal and (c) estimates.

2.4 Demand/consumption

Although the demand for various livestock commodities such as beef and milk are stagnating, it is predicted that the general demand for livestock products will increase (Scollan et al., 2010). The demand for meat and milk increased from 78kg and 202kg per capita per year

(2002) to 83kg and 203kg per capita per year (2015) in developed countries (Meissner *et al.,* 2013). In developing countries the same figures went from 28kg of meat and 44kg of milk per capita per year (2002) to 32kg and 55kg per capita per year respectively in 2015 (Meissner *et al.,* 2013). The per capita consumption of meat varies significantly between developed and developing countries. This spectrum can range anything from 200g/day to 20g/day (Meissner et al., 2013). The World Cancer Research Forum recommends a daily meat intake of 100 to 110 grams per capita per day (IMS, 2012), whereas others believe 50 to 100 grams per capita per day is sufficient to gain essential nutrients (McMichael and Ainslie, 2010).

Globally, there is a noticeable increase in the demand for meat (Scollan et al., 2010; Meissner, 2012) due to the increase in the human population, as well as an increase in wealth, especially in developing countries. The middle class of South Africa has increased significantly over the last 10 years with an associated increase in the demand for livestock meat. The assumption that the demand for red and white meat is increasing is supported by Table 2.6 (DAFF, 2017a). However, the reduced demand for red meat may be due to the higher price. Meat consumption in South Africa varies significantly and portrays extremes of developed and developing countries (Meissner *et al*., 2013). Although the meat consumption of South Africans has been studied, the actual figures are still lacking as previous studies focused more on smaller isolated populations (Meissner *et al.,* 2013). The available sources have been consulted to form possible consumption figures for South Africa. Demand for various meat types from 2000 to 2016 are presented in Table 2.6, of which the averages are compared to other sources in Table 2.7. The national consumption rate of meat can be estimated to be between 50 and 90 grams per capita per day, when Tables 2.8 and 2.9 are investigated. Red meat is estimated to be around 25 to 50 grams per capita per day, milk and other dairy products 120 to 130 grams per capita per day and eggs between 15 to 20 grams per capita per day. South Africa's consumption estimates are thus lower than the average for meat (105 to 110 grams per capita per day) and milk and other dairy products (530 grams per capita per day) in developed countries. In contrast, South Africa's estimated averages are higher than those compared to developing countries, which is 40 grams per capita per day for meat and 130 grams per capita per day for milk and other dairy products.

Table 2.8 - Demand and estimated consumption of livestock foods for the period 2000/1 to 2010/11 (g/capita/day) (DAFF, 2010).

Demand						
Year	Beef	Pork	Mutton & Goat	White meat	Milk & Dairy	Eggs
2000/1	33.7	7.12	9.59	58.9	122	19.4
2002/3	38.4	8.77	8.77	62.2	124	18.9
2004/5	42.5	10.7	8.77	70.8	127	19.3
2006/7	49.9	12.1	10.7	85.0	133[a]	22.6
2008/9	45.8	11.2	10.1	87.7	135[a]	25.3
2010/11	46.8	12.6	8.00	95.6		23.2
Average	42.9	10.4	9.32	76.7	128	21.5
Real[b]	25.7	6.24	4.66	30.7	124	19.4

Meat includes offal; [a] estimates; [b] estimates by the authors of the final cooked product after all waste and losses have been corrected for, thus providing real consumption (Bognár, 2002).

Table 2.9 - Comparison of the estimated consumption of meat and eggs with results of surveys in isolated populations (g/capita/day) (DAFF, 2010)

Food group	From Table 7	Survey 1983 - 2000[a]	Survey 2000 - 2010[b]
Meat[c]	67.3	Children 1-5 years = 45 Children 10+ years and Adults = 86	Children < 9 years = 58 Adults = 44-60
Eggs	19.4	Children 1-5 years = 7 Children 10+ years and Adults = 15	Children < 9 years = ND[d] Adults = 16.5

[a] Nel & Steyn (2002); [b] Van Heerden & Schönfeldt (2011); [c] Meat value includes consumption of red and white meat, meat products and offal; [d] ND: not determined.

South Africa's low meat consumption (compared to the amount recommended) and the extremely low average consumption of milk and dairy products raise major concerns about the underfeeding and malnutrition of the lower income population of the country. The FAO (2009) warned that lack of nutrition can lead to physical growth issues, regular infections, reduced intellectual capabilities, poor school performances and infants born under weight. It can thus be said that livestock meat is of vital importance to provide sufficient protein and other nutrients for the proper development of South Africa.

2.5 Socio-economic impact of the livestock industry

Food security is not only about the accessibility of food and food prices but is also an issue which has a major effect on unemployment. It is the responsibility of South Africa's government to create employment opportunities, which will allow the people to buy food for

their families. Unfortunately, between 1993 and 2005, the agriculture industry's contribution towards employment decreased by 75% and only employs around 628 000 farm workers (Agricultural Statistics, 2008). Total employment in the agricultural sector stood at 7.7% in 2001 and this decreased to 5.3% in 2016 (South African Survey, 2017). The sector has been recognized as a key focus area for creating employment opportunities in South Africa. The industry has the capability to uplift thousands out of poverty and ensure a better future for them and their families.

The livestock industry has always been a major employment provider in South Africa. Not only is the industry important for food security in South Africa, it also creates the jobs and income needed for households to buy food. It is estimated that the South African Agricultural sector employs some 875,000 people (Statistics South Africa, 2017), whilst the red meat industry employs 36 483 people (AgriSETA, 2018). It is estimated that the total employment in all agricultural, hunting, forestry and fishing sectors is about 15,833,000 (DAFF, 2017a). These figures are based on the estimation that there is about 50 000 commercial livestock farms in South Africa. However, after 1994 the number of commercial farms has been decreasing. One reason for the decrease in commercial farms is the increase in individually owned property sizes (Meissner et al., 2013). Moreover, there is also a decrease in employment in the livestock industry due to harsh economic conditions, rangelands being converted to wildlife production and eco-tourism facilities, an increase in labour costs and a decrease in intensive livestock management systems (Meissner et al., 2013).

Commercial farming activities in certain areas contribute to the development of towns in rural areas. In South Africa it is estimated that about 70% of the country's agricultural land is appropriate for livestock farming (DAFF, 2006; Goldblatt, 2010). With this being said, it can be agreed upon that the economies of these towns and peri-urban communities, usually poor, are significantly dependent on the money spent in these towns by the commercial and small-scale livestock farmers. For example, the towns of Calvinia, Richmond, Carnarvon, Petrusville and Victoria West in the Northern Cape are in sheep producing districts. A study of 26 commercial farmers in these areas showed they had an estimated net farm income per small stock unit of R248 during 2009 and 2010 (NWGA, 2011). It was further estimated that the farmers owned around 69 500 small stock of different species. The money earned by the

farmers and their employees would mostly be spent in the towns where they live on various basic items and goods. Moreover, general farming equipment would be purchased from stores in the surrounding regions, which proves that the success of those stores is mostly dependent on the money made by the farms in the area (Meissner *et al*., 2013).

As in other developing countries, the ownership of livestock is ever present in poor rural areas in South Africa. It is predicted that about two-thirds of poor households in rural areas will own livestock (Meissner *et al.,* 2013). The ownership of livestock can also be found in poor households in urban areas (Randolph et al., 2007). The municipalities often allow livestock to graze on commonly held land (Meissner *et al*., 2013).

Although the ownership of livestock in rural communities may reflect various challenges faced by the people, they also keep them for other reasons. Livestock products provide these households with vital nutrients. Usually livestock is only slaughtered for meat when they are sick or old, or when needed for various cultural rituals. Livestock serves as a backup in cases where the owners urgently need money. They will then use the livestock and sell them off at a market. The manure produced by the livestock is used to uphold the soil fertility, which will aid in improved crop production. Various livestock species can be used to plough lands or to transport goods, which otherwise would have been carried by humans, as cars are not as common in poor rural areas. Throughout rural communities in South Africa, the ownership of livestock is seen as an indicator of the person or family's social importance in that specific community. Moreover, livestock can be used to pay lebola for a bride – this, however, also depends on the social status of the family (Meissner et al., 2013). It can thus be said that livestock forms part of South Africa's poor rural communities' social lives and is indispensable to them.

2.6 Production costs and Affordability

Intensive farming practices rely on resources such as pesticide, synthetic fertilizer, herbicide, feed, water, fuel and genetically modified (GM) seeds to function (Goldblatt, 2010). The three most expensive resources are farm feeds, fuel and fertilisers, which prices are dependent on the oil price and the rand/dollar exchange rate. The farmer has no control over the prices of

these commodities. If farmers shift to farm-produced organic fertilisers and improve the fertility of their soils, the input costs will decrease and farmers would be less vulnerable to price fluctuations that are outside of their control (Goldblatt, 2010).

An increase in fuel prices has an effect on the operational costs of farm machinery and transportation. During the 1980's about 80% of grain was transported via South Africa's railway system, but due to its current poor state only 30% is nowadays transported by rail. The majority of the country's wheat is transported in trucks, which indicates how much rising fuel costs can impact farmers. Together with ever rising fuel prices, the cost of electricity is also increasingly placing more pressure on farmers.

In 2008 the global demand for fertiliser exceeded the supply rate. The combination of insufficient fertiliser, the expensive raw materials used in fertiliser production, and the high oil and shipping prices resulted in unaffordable fertiliser prices. These high international prices, together with a weak Rand, make it almost impossible for local farmers to compete against international farmers (Goldblatt, 2010). Fortunately South Africa has a fast-emerging biofuel industry, which has the potential to support the agricultural sector in terms of high fuel prices. In 2007 the Biofuel Strategy was implemented by the South African government – it can provide 2% of the country's annual fuel demand in the next 5 years (Goldblatt, 2010). It was estimated that 1,4% of arable land would be required to achieve the proposed goal. The government intended to exploit underutilized arable land in rural areas, which will also promote development and employment opportunities in rural areas. Although this project sounds good, it remains to be seen whether exploiting arable land for non-food production will benefit the country. If projects such as these are not sustainably managed, the impact it could have on food prices, food availability and the environment could be detrimental.

In the past food prices were considered to be relatively stable. However, during the last decade and a half food prices have increased due to higher fertiliser, transport and electricity costs, as well as the intense drought that has been negatively affecting southern Africa. It is estimated that the lower income groups spend more or less 33% of their income on food. An increase in food prices has the biggest impact on the livelihoods of the poor compared to the wealthier members of the population who only spend some 2% of their income on food

(Goldblatt, 2010). Moreover, the poor people living in rural areas have to travel longer distances to reach food markets, and this is a further burden to them.

With meat products becoming more expensive and thus less affordable for especially the poor, alternative protein sources may be needed to supply these population groups with the necessary protein they need.

2.7 Conclusion

The livestock industry is a labour intensive and rural industry, which has a vital role to play in creating employment opportunities and alleviating poverty in South Africa. Unfortunately, due to the mechanization of the industry and other factors, the employment rate is on the decline. The total number of people employed by the industry dropped from 1,6 million in 1971 (Agricultural Statistics, 2008) to 875,000 in 2016 (SSA, 2017). To put this into perspective – in relation to South Africa's population increase over that period of time – the industry's employment contribution dropped from 8,3% to 1,3%.

Moreover, with food prices on the rise and arable land becoming less and more degraded, alternative protein sources should be explored to provide the necessary protein requirements at an affordable price with minimal environmental impact.

It is of utmost importance that the South African government pays attention to the livestock industry (as well as alternative protein sources) in order to increase the employment of the sector whilst promoting sustainable farming practices that would be beneficial for both the country's economy, as well as its workforce and livestock.

Chapter 3: Environmental and Social Impacts

3.1 Introduction

As the human population increases, so does the demand for food sources such as meat. The livestock industry, together with its supporting practices, is part of the anthropogenic activities that result in some of the most devastating environmental damage. The industry also contributes directly and indirectly to global warming. The dilemma is that meat consumption cannot be easily reduced as the current demand exceeds the supply (Abbasi and Abbasi, 2016). The population of developed countries is estimated at consuming on average 95 grams of protein every day, whilst populations of developing countries consume on average 45 grams of protein per day.

Although the world is becoming more technologically advanced, one in eight people is still starving (FAO, 2014a, b). As the human population increases, towns expand into cities, and cities expand into mega-cities, the availability of arable land will decrease as the food demand increases (Abbasi and Abbasi., 2016). With the world already experiencing significant environmental harm, one of the key and difficult challenges being faced is to produce sufficient food to feed the world's burgeoning population, whilst minimising environmental degradation. This challenge is already difficult at the current rate the human population is expanding. What is even more frightening, is to supply this increasing human population with a sufficient amount of animal protein (Pimentel and Pimentel, 2008a). What makes this challenge even more daunting, is the fact that a large percentage of the world's population receives less animal protein than they desire, as well as the fact that to produce animal protein requires more resources (land, water and energy) to produce in comparison to other alternative food sources, with the same nutritional values (Abassi and Abassi, 2016). The damage caused to the environment is much more widespread in terms of soil erosion, pollution, decreasing biodiversity, global warming, and the exhaustion of water resources compared to the production of alternative food sources (Abassi and Abassi, 2016). As the environmental impacts of the livestock industry come under scrutiny, some have called for drastically decreasing livestock numbers, while others have pleaded for completely ending the consumption of animal protein (Brooks, 2010).

To drastically reduce or completely end the consumption of animal protein will have radical impacts. People's ability to provide for the basic needs of their families, employment, socio-

economic development, the country's gross domestic product (GDP), and the economy and livelihoods of small rural communities will be drastically impacted on. Many arguments are based on false information and in South Africa, with inadequate statistics and information, it is difficult to make concrete assumptions (Capper *et al*., 2009). It is thus important to look at the livestock industry in terms of the three pillars of sustainable development: social, economic and environmental impact of the sector. Once all these factors have been taken into account, only then can rational arguments and recommendations be made.

3.2 External cost of livestock farming

The livestock industry's agricultural practices have a direct impact on the environment. The industry is under scrutiny and more emphasis is being placed on how the food industry negatively impacts on the environment and human health. These impacts caused by industry do not only decrease the integrity of the environment and threaten our health, but it also comes at a financial cost. Impacts such as soil loss and erosion negatively affect crop yields and damage water systems (Evans, 1996). Agricultural runoff contaminates groundwater sources and disturbs aquatic ecosystems (Pretty *et al*., 2003). Practices such as monocropping and feedlot livestock production can decrease diversity and may increase foodborne pathogens and antibiotic resistance in humans, as well as pest resistance to chemical controls (Altieri, 1995).

The question should thus be asked whether human consumption of meat products could be sustained by the environment and what can be done to decrease meat consumption. The idea of increasing the price of meat based on the environmental damages being inflicted may be a good starting point. Most of these environmental consequences are inflicted involuntarily rather than purposefully because there is no formal market trading taking place for ecosystem functions or health attributes. The costs are carried by society. It is thus important to assess the financial burden these impacts produce in order to identify their consequences. These cost estimates can be used to inform and guide policy makers, agricultural producers, consumers and researchers and may further stimulate the movement to fully understand the impact of the livestock industry together with its supporting agricultural practices. The United Nations Sustainable Development Goal 12: Responsible Consumption and Production is a step in the right direction by including specific targets in this regard. (Griggs *et al*., 2013).

Private property rights, as classified in Western neoclassical economics, ensure that the property owner alone benefits from his or her property and that he/she is fully responsible for any costs incurred as a result of the property use (Tegtmeier and Duffy, 2004). However, this concept does not apply to the livestock industry with its concomitant agricultural practices, as it is the general public who will bear the consequences (costs) incurred by the industry and their decision makers. The general public has no say in what type of farming or slaughtering methods are used on different farms, which may have a direct impact on the surrounding environment. This is an example of where property rights are not well defined and represents a market failure, which could result in economic inefficiencies. In an unregulated scenario, the polluter (farmer) can calculate which scenario will be the most cost efficient in terms of production quantities, price per product and what quantity of resources should be allocated to cleaning up (Samuelson and Nordhaus, 1995).

The consequences occurring as a result of the practices are called externalities as they occur outside of the marketplace. One can distinguish between negative and positive externalities. Negative externalities are defined when costs are inflicted and positive externalities occur when the other party receives benefits without being charged. Economists distinguish between different types of externalities to identify actions that may cause it and what mitigation actions can be applied to limit its impacts. Externalities are generally categorized based on consumption (private or public) and its effects on resource allocation (technological or pecuniary).

An important factor of valuation is the fact that the economic value of any object or service is derived from the amount of satisfaction gained by the recipient. This can be measured by "establishing a link between the function and some service flow valued by the people" (Freeman, 1998). This measurement is based on what the consumer is willing to pay (WTP) to improve a specific object or service or the willingness to accept compensation (WTAC) for the degrading of the object or service (Farber *et al*., 2002). To evaluate a group or individual's WTP and WTAC, direct and indirect survey methods are usually used (Hanley *et al*., 1997). The surveys intend to measure whether the individual seeks an improvement of the object or service or what it will take for the individual to be satisfied with the deteriorating object or service. Indirect methods will observe and study the behaviour patterns in related markets.

Moreover, resource value is made up out of use values and non-use values that may prove difficult to delineate (Hanley *et al*., 1997). Non-use value relates to existence value, which is the value something receives purely based on the fact that the person is aware it exists, without even having any intention of using it. Non-use value also includes option value, which is the value something receives based on preserving it for possible use in the future.

The environmental impacts and resultant external costs can be categorized into three main categories:

1. natural resources consisting of water, soil and air resources;
2. wildlife and ecosystem biodiversity; and
3. human health

3.3 Environmental and Social Impact

3.3.1 Water Use

South Africa is challenged by a devastating water shortage and became the second region in the world to experience this confrontation (Turton, 2000). South Africa is classified as one of the most water-scarce countries in the world, which is exacerbated by its variable geographical and periodical rainfall. Only 12% of South Africa's surface is appropriate for rain-fed crops. The productivity of these crops is dependent on the amount of rainfall received, making farming very tough (Goldblatt, 2010). South Africa will face further challenges as climate change is predicted that will cause a decrease in rainfall occurrences, as well as more intense showers of rain. These impacts will result in a decrease of arable land in the country, as well as making farming more unpredictable. As the demand for food increases – because of the ever-increasing South African population – farmers will be under greater pressure to meet the country's demand. It is thus imperative for South African farmers to retain their land's soil integrity. It is estimated that South African farmers will double their water use by 2050 if the country's food demand is to be met, whilst using current farming methods (Goldblatt, 2010).

The irrigation of land has been used for centuries to increase productivity. Irrigation allows the area of arable land to be expanded, increases crop yield as well as allowing more frequent

crops per year. It is estimated that 1,5% of South Africa's land is being irrigated and produces 30% of its crops (South African Yearbook, 2008,9). One would think the obvious way to meet South Africa's ever-increasing food demand is to irrigate more land to expand the arable land area and increase crop yields for human and livestock consumption. However, it is estimated that only 1,5% of South Africa's land is irrigatable, which is already cultivated. As farmers expand irrigation practices to unsuitable land, the land actually becomes negatively impacted and will become degraded (Goldblatt, 2010).

Irrigation is already South Africa's largest water use, which is of major concern. It is estimated that around 63% of South Africa's available surface water is being extracted for the use of irrigation (refer to Figure 3.1 below) (Water Accounts for South Africa, 2000). It is estimated that 98% of South Africa's water resources are already being allocated for different uses, making the amount of extra resources for irrigation extremely limited as other industries also compete for more water (Goldblatt, 2010). Moreover, the exploitable aquifers in South Africa are very limited and are responsible for around 13% of the country's water supply. In the south-east of South Africa, more groundwater can be extracted but most of the country's groundwater is already being over exploited resulting in a significant decrease of the water tables (South African Yearbook, 2008/9).

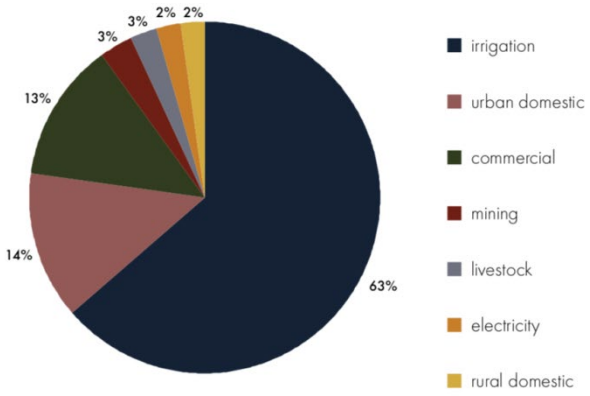

Figure 3.2 – South Africa's surface water withdrawal in 2000 (Total = 12,5km³) (Water Accounts for South Africa, 2000).

The Southern and Eastern Cape have been challenged by drought. This has indicated how vulnerable farmers in South Africa are when the amount of rainfall decreases. Farmers were forced to transport water and feed resources to their farms from all over the country, drill boreholes for water and sell their livestock in order to survive financially throughout the drought. The Eden District in the Southern Cape was classified as a Disaster Area in November 2009. Relief efforts, such as feed vouchers, were granted to the farmers in the area to survive

the drought. Ostrich and crop farmers did not receive any relief from the Government. The drought caused various farmers to be bankrupted in 2010 as they simply did not have the financial means to survive the dire situation. This is concerning as climate change will further impact the amount of water available to farmers and may soon lead to the water demand exceeding the supply (Goldblatt, 2010).

The livestock industry consumes more than 8% of the global human water usage. The bulk of this water is used to grow cropfeed for the animals. To put this statistic into perspective – only 0,1% of water goes towards industry, drinking and servicing (Abbasi and Abbasi, 2016). It is estimated that to produce one kilogram of soybeans, potato, rice or wheat requires 500 – 2000 litres of water. However, to produce one kilogram of beef requires approximately 43 000 litres of water (Pimentel, 1997). Moreover, larger amounts of energy and grain are used in meat production compared to other alternative food sources (Pimentel and Pimentel, 2008b). Not only is meat production resource intensive, but it also degrades land and results in severe soil erosion.

Due to the poor implementation and policing of policies, effluent from the livestock industry decreases the water quality of watercourses and streams in surrounding areas. Pollution of watercourses is caused due to the large amount of water used during cleaning and processing processes (Meissner *et al*., 2013). It was estimated that the annual water intake of abattoirs and dairy production facilities is 4,5 million m^3 with between 75% and 95% being discharged as effluent (Steffen *et al*., 1989a; b; c). To minimise the amount of effluent discharged by the industry, targets were set to reduce this wastage. It was calculated that the red meat abattoirs used 5,8 million m^3 water per year with each head of cattle using between 1,36 and 2,04 m^3 of water. Of the water intake, 80% to 85% was discharged as waste resulting in one head of cattle producing between 1,1 and 1,75m^3 of waste. It was estimated that poultry abattoirs consumed around 6 million m^3 of water per year with each bird consuming 17 to 20 litres. A water consumption limit of 15 litres per bird was set for A-grade abattoirs and 20 litres per bird for all other abattoir grades. Specific Pollution Load (SPL), as well as Chemical Oxygen Demand targets were also implemented to further reduce the impact of the industry. SPL targets of 29 grams COD/bird and 7 grams Specific Solids/bird were set for A-grade abattoirs

and 64 grams COD/bird and 14 grams Specific Solids/ bird were set for all other abattoirs (Meissner *et al*., 2013).

Currently it is not known whether the targets set for abattoirs and dairy facilities are still relevant or whether they should be updated. It seems as if some processors are oblivious of the targets set or that they do not care about meeting them. Water usage for the production of one litre of UHT milk varies between 2 and 3,2 litres, 15 - 20 litres of water per kilogram of semi-hard cheese, 15 – 50 litres per kilogram of milk powder and 7 – 10 litres per kilogram of yogurt. To ensure the sustainability of the industry, these high water usage levels and discharged effluent need to be addressed (Meissner *et al*., 2013).

3.3.2 Water quality

The effect that the livestock industry has on one of the planet's most valuable resources, if not the most valuable, can be assessed based on what the price would be to treat and control deadly pollutants contaminating our water resources due to livestock practices. These pollutants include microbial pathogens, nitrate and pesticides, which are all linked to the livestock industry.

Microorganisms that occur within livestock waste can result in various diseases and can cause major human health risks. Two waterborne parasites that can result in diseases are Cryptosporidium and Giardia (Tegtmeier and Duffy, 2004). Both microorganisms can be found in beef herd with Cryptosporidium occurring in diary operations. Cryptosporidium oocysts was found to exist in 67 to 97% of the United States' surface water (Tegtmeier and Duffy, 2004).

Giardia and Cryptosporidium both have three potential sources from where they can originate, being humans, wildlife and domestic livestock (Pell, 1997). One can thus assume that each possible source represents a third of the damages caused by these pathogens (Tegtmeier and Duffy, 2004). Once a monetary value is assigned to the damages caused by these pathogens, a third of the value can be allocated directly to the livestock industry.

Water availability and quality heavily impact land management practices that occur on farms. Erosion occurring on farms can cause the loose soil to end up in streams or rivers, which will change their flow patterns and reduce the storage capacity of dams situated further downstream. Due to these impacts, expensive treatment and/or filtration systems need to be installed to treat the water before it can be used for industrial or domestic purposes. Fertilisers that are incorrectly applied can contaminate streams or rivers, which pollutes water sources and cause algal blooms to occur. Algal blooms result in the reduction of dissolved oxygen in water sources, which in turn produces toxins and ultimately kill aquatic life forms in the affected area (Goldblatt, 2010).

Moreover, poor fertiliser management occurring on farms can also lead to major pollution of water sources, with severe impacts on the health of the surrounding humans and the environment. Pimental and Levitan (1986) found that only 0,1% of pesticide being sprayed on crops reaches the targeted pest – the rest reaches the surrounding environment. Downstream of a farming area, very high levels of pesticide were detected during a water quality study of the Lourens River in the Western Cape (Dabrowski *et al*., 2002). The contamination level of the water was higher than the national water quality standards, as well as what the US Environmental Protection Agency (EPA) recommends. What was of major concern was the detection of high levels of endosulfan, a pesticide chemical which is a highly toxic bio-accumulating neurotoxin and endocrine disruptor that has been banned in over 50 countries (National Resources Defence Council, 2008).

Nitrate is a compound of nitrogen and is increasingly being used in the modern era of farming practices. It can contaminate surface water through leaching into groundwater sources or being deposited by soil particles via runoff. Nitrate can be found in fertilisers, livestock waste and mineralization of crop residues. It is known that the surface and groundwater sources of areas with a high agricultural presence are more susceptible to nitrate contamination. Nitrate causes major damage to precious aquatic ecosystems and can be detrimental to human health. Infants are especially vulnerable to the dangers of nitrate as it can be transformed into nitrite within the gastrointestinal tract. This may hamper the transport of oxygen in the bloodstream, causing methemoglobinemia, also known as blue-baby syndrome (Tegtmeier and Duffy, 2004).

It is imperative that farmers manage their livestock's manure effectively as antibiotic deposits, veterinary drugs and food borne pathogens (Salmonella strains and E. coli) can contaminate watercourses and be incorporated into the food chain (Holtslander, 2007; National Resource Defence Council (NRDC), 2013). Farmers can make use of anthropods to break down waste and form assets that can be utilised (Pieterse, 2013).

3.3.3 Soil

Soil erosion occurs due to ploughing, cultivation and harvested land that is left exposed. These actions make soil vulnerable to water and wind, which can move the soil particles resulting in erosion. Although natural factors contribute immensely to soil erosion, the major contributor is agricultural practices (Tegtmeier and Duffy, 2004). Soil erosion impacts massively on the condition and use of surface water, thus integrated land and water policies should be clearly defined and in place.

The different effects of erosion on soil can have major financial costs. It reduces the water-holding capacity and organic matter of soil and has a negative impact on soil productivity (Tegtmeier and Duffy, 2004). Externalities may become more severe in instances where more pesticides and fertilizer are being used to respond to some of these negative impacts. The cost of preventing and responding to possible soil erosion situations should be evaluated to determine a monetary value, which should be incurred by the perpetrator.

Organic fertilisers in the form of manure, plant matter, lime, bones, urea and shells, have been used to improve soil fertility since ancient times. Artificial fertilisers were developed in the 17th century and became very popular after World War One. Companies that produced ammonia and nitrates for explosives during the aforementioned war started producing nitrogen fertilisers. South Africa's fertiliser industry merged with the mining industry, which required the manufacturing of explosives (Goldblatt, 2010).

The positive impact fertiliser had on soil fertility and plant growth mainly powered the Green Revolution that took place during the 20th century. The natural environment was protected

as fertiliser increased the production potential of the land preventing the expansion of agricultural activities into the natural surrounding areas. However, environmental damage can occur when natural and artificial fertilisers are extensively used. It can pollute groundwater when it is released into rivers, and also when applied nitrogen is released into the atmosphere as nitrous oxide – the latter is a Greenhouse Gas (GHG) 300 times more powerful than carbon dioxide.

Soil fertility can be negatively impacted when artificial fertilisers are incorrectly applied (Mulvaney *et al*., 2009). If only artificial fertilisers are being used, the organic matter and life in soil will decrease. Ultimately the soil will become lifeless and will only offer physical support for plants to grow in. The farmer may increase the usage of fertiliser to combat the decreased soil fertility. If the malpractice of fertiliser continues, the soil will become acidic and salty, and may contain high levels of toxic metals and radioactive elements (Goldblatt, 2010).

It is estimated that 5 million acres of cultivated land have been completely acidified in South Africa due to the malpractice of artificial fertiliser (SA Yearbook, 2008/9). The damaged soil becomes more susceptible to erosion and the topsoil becomes less fertile and absorbs less moisture and water (WWF).

It is estimated that 69% of South Africa's land surface is appropriate for grazing. Livestock farming is thus the country's largest agricultural sector. Since the 1970's the country's number of cattle herd has increased by approximately 6 million and is now estimated to be around 14 million (Palmer and Ainslie, 2006). The high demand for meat in South Africa has almost been met with the ever-increasing cattle herd numbers.

A major problem in South Africa is overstocking. Most of the grazing land in South Africa is stocked with livestock numbers that exceed the land's long-term carrying capacity. Overstocking is a common occurrence in the communal rangelands of Limpopo, Eastern Cape and KwaZulu-Natal, where more than 50% of South Africa's cattle is supported. Overstocking will result in the trampling and crusting of soil and eventually strip the area of all vegetation. Denuded areas will have a lower productivity rate and soil fertility, and will be more susceptible to erosion. Some 91% of South Africa's land surface is classified as arid and semi-

arid. It is in these areas where land degradation together with the impact of climate change will potentially lead to desertification and the permanent loss of land that could have been used for productive activities (Gbetibouo and Ringler, 2009).

Various farmers attempt to improve the carrying capacity of their land by increasing the amount of fertiliser being used, introducing pastures or by introducing palatable species, which is also referred to as reinforcements. These methods all require the use of fertilisers, which are financially and environmentally expensive. If the application of fertiliser is misused, the affected area's species composition can be altered and the basal grass cover may decrease. Thus, instead of the land's productivity being increased, it becomes less productive, and water runoff and erosion will become more frequent. Irrigation is usually needed to cultivate and maintain pastures. Moreover, the use of the restricted water resources may result in soil salinisation. The use of fertiliser and irrigation on non-arable land is very expensive and cannot be afforded by most farmers. These so called "improved" pastures also have detrimental effects on grassland bird and insect species as their natural habitats are being altered as well as the nutrients and animal species found in these areas (Goldblatt, 2010).

3.3.4 Air Quality

The agricultural practices associated with the livestock industry have an immense impact on the world's air resources. Air resources become polluted through particles being discharged through soil erosion, the evaporation of ammonia (NH_3) from manure fertilisers and urea, field burning, fertilizer applications and soil denitrification emitting nitric oxide (NO) and nitrous oxide (N_2O), manure storage resulting in hazardous pollutants being emitted, and enteric fermentation and eructation emitting methane (CH_4) gas (Tegtmeier and Duffy, 2004; Thorne, 2007).

Various gasses emitted into the atmosphere by the livestock industry are greenhouse gasses, which have a negative impact on human and environmental health. Some of these gasses contribute to global warming, negatively impact pulmonary and respiratory functioning, weaken construction materials and result in the acidification and eutrophication of water resources (Tegtmeier and Duffy, 2004).

The overall impact of the industry is reduced agricultural soils absorbing carbon. Moreover, policies are being drawn-up and implemented to further promote carbon sequestration. Programmes are being implemented where corporations, municipalities and other organizations can trade greenhouse gas credits. These programmes aim at achieving the most cost-effective ways to reduce the overall greenhouse gas emissions (Chicago Climate Exchange, 2004). As institutions decrease their emissions, they are rewarded with credits, which can then be sold to other parties. A monetary value is assigned to a tonne of carbon dioxide for example. A price can then be calculated for the amount of gasses reduced, which is reimbursed to the institution in the form of the credits. The price for these credits depends on what companies are willing to pay for reducing their emissions or increasing them. So far, this system is not compulsory and companies can choose to participate in it or not.

The percentage of emissions that the livestock industry together with its supporting practices are responsible for, should be calculated and incorporated into the cost to the environment.

3.3.5 Wildlife and Biodiversity

The livestock industry together with its supporting practices has considerable impacts on insect, bird and fish populations, which subsequently affect the biodiversity of ecosystems. The stability of ecosystems is severely impacted by pesticides used with its approximate 447 million kilograms of active ingredients used in the industry (Tegtmeier and Duffy, 2004). Although these pesticides are extremely influential in destabilizing ecosystems, one must remember that the production companies of these pesticides do research to decrease the toxicity of their products. One example of this was when the use of granular carbofuran was restricted (Pesticide Management Education Program, 1991). However, fish are still killed through manure spills. Moreover, inorganic fertilizer flowing into water bodies significantly impacts the aquatic ecosystem and monocultural practices suppress biodiversity (Tegtmeier and Duffy, 2004).

3.3.5.1 Honeybee and pollination losses

Insects, such as honeybees, act as vital pollinators that ensure stability in ecosystems and the agricultural industry. Various studies have tried to evaluate the importance of pollinators to

the agricultural industry. It is important to calculate a realistic value of what pollinators are worth to the industry, as well as how many pollinator colonies are lost due to the livestock industry.

3.3.5.2 Loss of beneficial predators

The use of pesticide on crops does not only affect the targeted pest, but also the natural predators of the pest. The pesticide will initially kill the targeted pest, which will result in the numbers of beneficial insects diminishing. This chain reaction will further lead to secondary pests occurring, which will force the farmer to apply more pesticide (Tegtmeier and Duffy, 2004). To calculate the external cost pesticides cause, the cost for these additional pesticide applications – and crop losses associated with new pest outbreaks – should also be determined. These costs can be determined on the farm, but it should be remembered that the loss of beneficial insects does not only impact the specific farm's crop production but also the entire ecosystem in the given area. Moreover, microorganisms occurring in the treated area may also be impacted. Soil and ecosystem health is measured by the amount of microorganisms occurring in the soil. Microorganisms play the vital role of breaking down organic matter and recycling nutrients occurring in the soil. Thus, if microorganisms are decreased as a result of pesticide use, then the soil and ecosystem health is also heavily impacted (Tegtmeier and Duffy, 2004).

3.3.5.3 Fish kills due to pesticide

Pesticides can contaminate aquatic environments, which poison the fish and damage their habitat and food sources. To calculate the external cost of pesticides on fish-kills is challenging. It is extremely difficult to count big fish-kills and to detect low-level poisoning occurring in aquatic environments.

3.3.5.4 Bird kills due to pesticide

Pesticides can poison birds directly or they can consume a food source that contains pesticides. Pesticides have a major impact on the life cycle and reproduction of birds. Birds are also more indirectly impacted through the effect pesticides have on their natural habitat.

The excessive impact that pesticides have on the environment proves that further research on their effect is required. In order to prevent harmful impacts caused by manure spills, farms should be regulated and inspected more often to ensure the proper disposal of manure at licensed waste disposal sites.

3.3.5.5 Impact on land-use

The livestock industry occupies vast areas of land and exerts a major impact on it through the grazing of animals as well as the production of feedcrop. The FAO (2006) estimates that about 30% of the earth's surface – excluding the polar terrestrial surface – is being utilised by the livestock industry. In areas where livestock is present, the surrounding environment is usually polluted by the released nutrients, organic matter, pathogens and drug residues. These pollutants contaminate the soil, coastal areas and watercourses (Abbasi and Abbasi, 2016).

Livestock production causes major land-use changes as forests and other natural environments are destroyed to make space for more pastures and fodder-producing monocultures (Abbasi and Abbasi, 2016). Changing natural environments and forest into pastures and areas suitable for only certain plant and animal species, has a major impact on the biodiversity of the immediate environment. On a global scale, this conversion of land into pastures and feedcrop areas can be fully grasped by taking the Amazon forest into consideration. It is estimated that 70% of the Amazon basin has been transformed into pastures and most of the remaining 30% into cropfeed areas, which support the livestock (Abbasi and Abbasi, 2016). Steinfeld *et al*. (2006) estimates 78% of the global agricultural land and 33% of cropfeed areas exist to support the livestock industry.

Vital agricultural services are provided by natural ecosystems. These services include an increase in the availability and purification of water resources, pollination, grazing, protection against natural hazards, improving the soil fertility and regulation of the climate. The world's natural ecosystems have been altered dynamically during the last 50 years due to anthropological activities. It is estimated that 34% of South Africa's ecosystems are threatened due to land transformation – 5% of these are critically endangered.

Both natural and agricultural ecosystems consist of various species that provide specific functions in order for the ecosystem to function properly. Habitat loss and fragmentation are

caused by anthropogenic activities that result in a decrease of species and eventually also in the ecosystem's functioning (Goldblatt, 2010). Since the 1970's more or less 30% of the world's plants and animals have been eradicated. The current extinction rate is estimated to be 100 times faster than that indicated by the fossil record (Goldblatt, 2010).

Ecosystem services are drastically decreasing in the semi-arid Little Karoo, which is now classified as one of the Western Cape's most degraded areas. Overgrazing in this region has resulted in the area being over 52% degraded (Reyers *et al*., 2009). It is extremely worrying, as the region has suffered an 18% decrease in water-flow regulation and a 44% decrease in erosion control (Goldblatt, 2010). These two natural occurrences are of vital importance to the surrounding agricultural industry and can have detrimental financial implications. With the decline of these two ecosystem services, the Little Karoo's longevity in terms of producing agricultural goods and its resistance against market shifts and natural forces such as floods and droughts, come into question. In order to resolve this current crisis in the Little Karoo, the various ecosystems will need to be improved. This means that extensive conservation and restoration operations should be implemented and focus should be placed on water flow and erosion control. Unfortunately, recovery of ecosystems in semi-arid ecosystems takes time.

The diversity of agricultural species has been decreasing due to the tendencies of using limited monoculture species. It is estimated that around 75% of the world's agricultural crops have been lost during the last 50 years. Moreover, it is estimated that 20% of different breeds of poultry, cattle, horses, pigs and goats are being threatened by extinction (Goldblatt, 2010). As different species become extinct, so does their ability to adapt to extreme climates or resistance to diseases. Staple crops such as sorghum and millet have lost their status in Africa. Rigorous action should be taken to ensure that these crops survive. A major flaw in society is that the general public cannot observe how the world is currently busy losing its genetic diversity when standing in a grocery store and looking at the variety of breads and meat available. Other than that, the decline of fruits and vegetables are covered up by providing the public with imported produce.

Humanity's chances of surviving in the future decreases more and more as species and genes are lost due to anthropogenic influences. The genes of agricultural crops' wild relatives are

being used to increase food crops' nutritional value, the resistance against diseases and their productivity (Goldblatt, 2010). However, the existence of wild diverse gene pools is being threatened by human intervention. Currently, for every 20 Poaceae species, more than one is being threatened by extinction. These species are related to crops such as millet, wheat, barley and maize. During 2007, the origin of today's cultivated apricot species, *Armeniaca vulgan*, was officially classified as Endangered on the IUCN Red List (Goldblatt, 2010).

3.3.6 Human health

Food transmitted diseases cause a staggering number of deaths, illnesses and hospitalizations in South Africa (Goldblatt, 2010). Microbial foodborne diseases also cause diseases and deaths, which further impacts the population's life quality and expectancy. This external cost can be calculated by evaluating the cost to treat associated illnesses, – also the cost to the food industry to adhere to all the regulations in order to reduce pathogen caused illnesses. Iowa State University and the University of Iowa Study Group (2002) have raised their concern about the day pathogens will build up antibiotic resistance (Tegtmeier and Duffy, 2004). The death toll of people will rise dramatically as our bodies won't be able to fight the pathogens.

3.3.6.1 Cost of foodborne illness

Microbial foodborne disease usually originates during the processing and packaging stages of animal products. It is estimated that more than 90% of foodborne diseases can be eradicated by changing food processing and handling methods (Tegtmeier and Duffy, 2004). Thus it can be said that 10% of foodborne diseases originates during the production and meal preparation phases.

Foodborne diseases can be caused by bacterial, viral, parasitic or fungal pathogens (Tegtmeier and Duffy, 2004). Common pathogens associated with foodborne diseases include Campylobacter spp., Salmonella, E. coli and Listeria monocytogenes. Moreover, bacteria such as Clostridium perfringens and Staphylococcus aureus as well as the parasite, Toxoplasma gondii can cause foodborne diseases that could harm human health (Tegtmeier and Duffy, 2004). These agents are the most common pathogens. However, most illnesses are caused by unknown agents. In the United States, the Center for Disease Control and Prevention (CDC) has estimated that 82% of foodborne diseases and 65% related deaths are the result of

unknown agents (Tegtmeier and Duffy, 2004). Moreover, many foodborne disease cases are not reported or even diagnosed as a food-related disease (Tegtmeier and Duffy, 2004).

The external cost that the livestock industry, together with its supporting practices, are responsible for can be estimated by calculating the number of foodborne diseases occurring per year and what percentage is due to the livestock industry.

Although it is thought that most foodborne diseases originate during the processing and packaging phases of animal products, production methods and the health of livestock do contribute significantly to diseases and should thus be further investigated to address the issue of food safety. It is becoming more evident that the use of antibiotics for livestock purposes contributes to pathogens becoming more resistant to antibiotics (Iowa State University and the University of Iowa Study Group, 2002). This emphasises the need to undertake more research to better understand the production phase of animal products to prevent detrimental health incidents.

3.3.6.2 Pesticides

Pesticides can threaten human health in various ways including coming into direct contact with it, the release of it into the environment and through food being contaminated by pesticides. Depending on the amount and toxicity of the pesticide that the person was exposed to, it can cause various impairments. The person can be poisoned, ocular damage can occur, respiratory diseases can arise, the endocrine system can be disturbed, the nervous system can sustain damage, defects by birth can occur, and cancer and other defects can occur over a long period of time (Tegtmeier and Duffy, 2004). One of the greatest concerns is pesticides that disturb the endocrine system. It is estimated that some 35% of food purchased in grocery stores is contaminated by pesticides (Tegtmeier and Duffy, 2004). People who come into direct contact with these food products, such as farm workers who apply and work with pesticides, are particularly vulnerable to experience various effects.

It is important to quantify the percentage of pesticide inflicted cases due to the livestock industry. The cost to treat these infected patients, the loss of work time, deaths, as well as the cost for long term treatment measures, should be accounted for by the responsible sectors in order to compensate for this external cost. Moreover, it is evident that more

research should be conducted to study the human and environmental effects that can be caused by using chemicals in the agricultural industry.

3.3.6.3 Conflict, hunger and diseases

The livestock industry has a heavy impact on the quality of natural resources such as the air, water and soil. The United Nations has identified environmental degradation as one of the main causes of conflict in African countries such as Darfur and Sudan (UNEP, 2007). Climate change can thus further intensify situations, as it will cause environmental problems. The temperature in South Africa is predicted to rise with climate change, which will result in the country's water resources becoming scarcer. Farmers and herders may have to become aggressive in order to control arable land, which will become a scarce commodity in times of desperation (Baldauf, 2006). The Secretary-General of the United Nations, Ban Ki-Moon, predicts that conflict and war will be intensified – and caused by global warming – bring about more frequent and intense natural disasters (United Nations, 2007).

The IPCC (2007a) warns that areas that are already affected by droughts will become drier, which will further worsen hunger and diseases occurring in those areas. By the year 2020, the IPCC (2007a) further estimates that more than 250 million people will face water shortages, and that food production may be 50% less than what it was in 2007. Casey (2007) predicts that by the year 2050, more than 130 million people in Asia will suffer from food shortages as a direct result of impacts from climate change. This is the same year that meat and dairy production is estimated to be double the present levels (Steinfeld *et al*., 2006). Moreover, it is believed that as forests are cut down for soy-bean production, viruses are enabled to exploit these new niches, which can further lead to new or more serious health risks (Greger, 2007).

3.3.7 Contribution to Global Warming

The presence of greenhouse gasses (GHGs) in the earth's atmosphere is natural and various natural processes contribute to the emissions of GHG (IPCC, 2007c). However, the current scientific consensus view supports the idea that human activities are the main driver behind global warming (IPCC 2007a). In 2007 the IPCC (2007a) stated with high confidence "that anthropogenic warming over the last three decades has had a discernible influence on many physical and biological systems." It is foreseen that global warming will cause southern Africa

to become drier and warmer as the emissions of GHGs increases (Kruger and Shongwe, 2004; Engelbrecht *et al*., 2009). The South African government has taken various precautions and has accepted the need to focus on climate change as stated in the White Paper on the National Climate Change Response (Department of Environmental Affairs (DEA), 2011). It has been calculated that 60% of South Africa's total agricultural carbon dioxide emissions is caused by the livestock industry (Blignaut *et al*., 2005; Taviv *et al*., 2007; Otter *et al*., 2010). That is a dramatic increase compared to the average total carbon dioxide emissions of 8,5% of the entire agricultural sector during 1990 – 2000 (Department of Environment and Tourism (DEAT), 2009).

The technological advanced regional conformal-cubic atmospheric model (CCAM) provides accurate climatological information, which can be applied to make annual rainfall and temperature projections on an accurate scale. The CCAM indicated that a rise in average air temperature of between 1,5°C and 2°C can be expected. When the 10% and 90% percentiles are included in the measurement, an increase in average temperature ranges from 0,5°C near the coastline to about 3°C in eastern Namibia and western Botswana (refer to Figure 3.2 below) (Meissner *et al*., 2013). Percipitation predictions are not looking good for South Africa. It is predicted that a decrease in rainfall of a minimum of 40mm/annum can be expected for the south western Cape, the Cape south coast, and the eastern areas of Limpopo and Mpumalanga. Overall South Africa will become drier with the exception of the Eastern Cape and the central interior regions, which will experience more rainfall (Meissner *et al*., 2013).

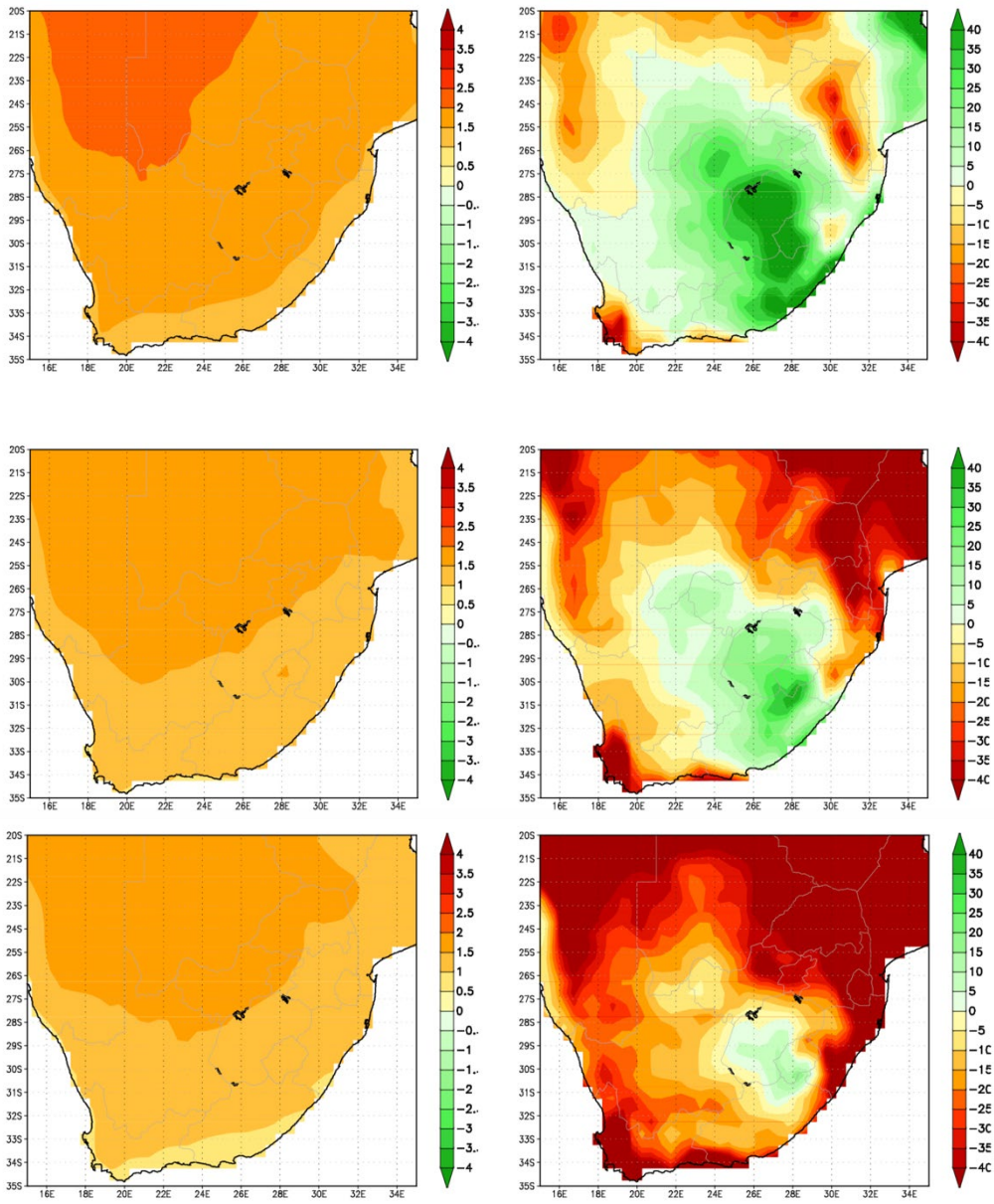

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Figure 3.2 - Predicted change in average annual air temperature (°C, left) and annual total rainfall (mm, right) over southern Africa, between 2021 and 2050 (Meissner, et al., 2013).

frequent towards 2050. This reduction in potential rainfall will result in less water available for livestock and for the irrigation of feedcrops and pastures (Meissner *et al.*, 2013). It is thus imperative to improve water storage and management of water resources in impacted regions. In a statement on 17 August 2017, the Executive Mayor of Cape Town said the following about the water crisis: "…we believe we are within a scenario called The New Normal – a scenario in which we do not bank on the drought ending, but rather actively plan as if it will continue indefinitely." The central interior regions, as well as the Eastern Cape

must also plan thoroughly as their increased rainfall will come in the form of heavy storms, which may increase runoff (Engelbrecht *et al*., 2009).

Various impacts of global warming are currently being experienced. The retreating of ice glaciers, the rise in sea levels, tundra thaws, more frequently occurring extreme weather events and various species that are struggling to survive, have all been documented (Topping, 2007). Since the 1890's the five hottest years recorded were 1998, 2002, 2003, 2004 and 2005 (National Aeronautics and Space Administration, 2006). Moreover, the average temperature on a global scale has been rising significantly and it is predicted that by 2100 that average temperature will increase by 1,8 – 3,9°C (Intergovernmental Panel on Climate Change, 2007c). Average temperatures have been rising – comparing this century to the last, the rise in temperature per decade has tripled (National Oceanic and Atmospheric Administration, 2007). Also the IPCC (2007b) has warned that climate change can result in sudden or irreversible impacts.

When the topic of global warming is discussed, usually the first industry that springs to mind is that of transport and the burning of fossil fuels. However, a recent study (Steinfeld *et al*., 2006) found that when the contributions of the livestock industry to global GHG emissions were calculated, measured in carbon dioxide equivalent, the emissions are far greater than those of the whole transportation sector combined. There are three main GHGs, which include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Steinfeld *et al*., 2006). Carbon dioxide is considered to be the most significant GHG. Carbon dioxide impacts global temperature rises the most due to the amount that is being emitted into the atmosphere through deforestation and the burning of fossil fuels (Koneswaran and Nierenberg, 2008; Bierbaum *et al*., 2007). However, methane and nitrous oxide have higher global warming potentials (GWP) compared to carbon dioxide (Koneswaran and Nierenberg, 2008). Carbon dioxide has a GWP of 1 whereas methane and nitrous oxide have a carbon dioxide equivalent GWPs of 23 and 296, respectively (Paustian *et al*., 2006; Koneswaran and Nierenberg, 2008).

It is estimated that the livestock industry produces about 35 to 40% of the global anthropogenic methane emissions and 9% of the world's carbon dioxide emissions (Abbasi and Abbasi, 2016). The livestock industry plays a major role in emitting nitrous oxide, which

is the most potent GHG. It releases 65% of the world's total anthropogenic nitrous oxide emissions. Nitrous oxide forms about 75-80% of all the agricultural emissions. It is predicted that this rate will significantly increase during the forthcoming decades (Abbasi and Abbasi, 2016). This impact is caused together by deforestation, pasture degradation, as well as direct emissions from livestock. The high demand for animal protein results in the industry being responsible for deforestation on a massive scale in order to make space for pastures for grazing or croplands for feedcrop to sustain the estimated 56 billion animals humans slaughter per year (FAO, 2008). The industry is directly responsible for the mass eradication of forests in Latin America and the largest release of stored carbon into the atmosphere due to vegetation being removed (FAO, 2005). Cultivated soils that are related to the industry are responsible for 28 million metric tons of carbon dioxide annually (Koneswaran and Nierenberg, 2008). The planet's soils act as carbon sinks and store about double the amount of carbon that occurs in the atmosphere or in vegetation. However, as deforestation and other livestock industry related activities occur, the amount of carbon sequestered in the earth's soils has been dramatically depleted, which contributes significantly to GHG emissions (Koneswaran and Nierenberg, 2008).

It is estimated that 80% of the methane emissions that the livestock industry is responsible for, is solely due to enteric fermentation and manure (Abbasi, *et al*., 2013; Abbasi and Abbasi, 2016). Methane aids significantly by the formation of black carbon, which is a heating agent that causes ice masses to melt, as well as the production of tropospheric ozone (Wedderburn-Bisshop and Pavlidia, 2011). Manure is concentrated on small landmasses, which results in soil accumulation and runoff contaminated with nitrogen, phosphorus and various other pollutants (Thorne, 2007). Moreover, livestock urine and manure are responsible for 64% of the global anthropogenic ammonia emissions (Abbasi and Abbasi, 2016). Ammonia is not classified as a GHG, but specialised soil bacteria convert it into nitrous oxide (Abbasi and Abbasi, 2016). It is estimated that the entire process to raise, maintain and utilise livestock, contributes to 18% of the total anthropogenic GHG emissions. This makes the livestock industry the second largest contributor to global warming after the energy sector. It can thus be said that the industry is one of the main perpetrators of climate change, as well as global pollution (Abbasi and Abbasi, 2010a).

The world's livestock population consumes more than 80% of the global soybean production and more than 50% of the world's corn production, which is grown using nitrogen-based artificial fertiliser (Koneswaran and Nierenberg, 2008). Fixed sources of nitrogen occur naturally, but unfortunately its abundance is limited. For this reason, artificial fertiliser is produced to meet the world's high demand. Prior to the Haber-Bosch process, bacteria and lightning were the only two producers of nitrogen that were available for plants. Through this natural production of nitrogen, life on earth was kept at a sustainable threshold (Koneswaran and Nierenberg, 2008). The production of artificial nitrogen is highly dependent on the burning of fossil fuels and has made a natural nutrient – previously limited by natural production – abundant and easily available to crop farmers and the entire world. Elizabeth Holland stressed that: "The changes to the nitrogen cycle are larger in magnitude and more profound than the changes to the carbon cycle… but the nitrogen cycle is being neglected" (Koneswaran and Nierenberg, 2008). Another nitrogen cycle expert, Vaclav Smil, agrees with Elizabeth Holland when saying: "We have perturbed the global nitrogen cycle more than any other, even carbon" (Pollan, 2006). It is thus worrying that most of the developed world's crops are heavily treated with nitrogen, which threatens the integrity of surrounding environments through nitrogen runoff into water-ways and its occurrence in animal manure.

It is known that livestock which is confined is generally fed corn and soybeans, which are high in protein and is not the animals' natural diet. Feeding livestock these unnatural diets increases the animal's weight gaining process, but can also result in various illnesses (Koneswaran and Nierenberg, 2008). Moreover, methane emissions may also increase as a direct impact of unnatural diets. It has been found that confined cattle raised for beef excrete manure with a higher methane producing capacity than when fed a normal diet (Koneswaran and Nierenberg, 2008). In fact, the methane producing capacity of cattle ranging on pastures eating a low-energy natural diet, is less than half of that compared to confined cattle (Koneswaran and Nierenberg, 2008).

Livestock produces billions of tons of solid and liquid waste annually (U.S. EPA, 2003). When this waste is stored and disposed, high amounts of anthropogenic methane and nitrous oxide are emitted (Koneswaran and Nierenberg, 2008). It is estimated that the pork industry's manure contributes to about 50% of all GHG emissions caused by all livestock manure

(Koneswaran and Nierenberg, 2008). The total combined methane emissions of livestock is estimated around 18 million tons of methane annually (Koneswaran and Nierenberg, 2008). A rise in methane emission from dairy cow and pig manure of 50% and 37% respectively, was observed between 1990 and 2005 in the United States (Koneswaran and Nierenberg, 2008). This sharp increase was as a result of the tendency of placing the animals in larger facilities that make use of liquid manure management systems (Miner *et al*., 2000). The system was first used in the 1960's and is now implemented in large dairy farms and pig operations in developing countries, such as South Africa.

The burning of biomass is another huge contributor to GHG emissions. Grassland, woodland and savanna biomes have to be burned regularly to maintain grass cover for grazing in order to prevent the development of thicket (Tainton and Hardy, 1999). Fires have been an important contributor in the evolvement of climax grasslands within the eastern areas of South Africa and in areas, which would have developed into forest or savanna (Tainton, 1999). Burning grasslands has thus become an acceptable method to maintain pastures for livestock production (Meissner *et al*., 2013).

Prior to the use of man-made fires to maintain rangelands, fires were naturally caused mainly by lightning. These fires occurred less frequently than those intentionally ignited by farmers, which contributes greatly to changes occurring in the atmosphere and ecosystems (Fearnside, 2000). The intentional burning of biomass unnaturally emits carbon into the atmosphere, as well as indirectly through the remaining decomposing material and from bare soil (Fearnside, 2000; Mouillot and Field, 2005). Black carbon forms part of the emitted gasses (Ito and Penner, 2005). Moreover, these fires have long-term impacts. The carbon budget of the burned areas and surrounding ecosystems is influenced due to the breakdown and regrowth of biomass, as well as the internal reorganisation of the system (Mouilot and Field, 2005). Also, the amount of carbon lost through biomass burning is only partly regained as the vegetation starts to regrow, leaving the carbon budget in a negative state (Stringer *et al*., 2012). There is overwhelming evidence which indicates that these unnatural fires cause various negative environmental impacts and that this management method should be more restricted and controlled to minimize impacts.

3.4 External cost valuation

The above sections 3.3.1 – 3.3.7 outline the various environmental and social impacts of the livestock industry. The physical impacts as such point to the need for policy intervention and presenting arguments for a reduction in meat consumption and production. Putting a monetary value on the impacts further informs policy decisions.

An important factor of valuation is the fact that the economic value of any object or service is derived from the amount of satisfaction gained by the recipient. This can be measured by "establishing a link between the function and some service flow valued by the people" (Freeman, 1998). This measurement is based on what the consumer is willing to pay (WTP) to improve a specific object or service or the willingness to accept compensation (WTAC) for the degrading of the object or service (Farber *et al*., 2002). To evaluate a group or individual's WTP and WTAC, direct and indirect survey methods are usually applied (Hanley *et al*., 1997). The surveys intend to measure whether the individual seeks an improvement of the object or service or what it will take for the individual to be satisfied with the deteriorating object or service. Indirect methods will observe and study the behaviour patterns in related markets. Moreover, resource value is made up of use values and non-use values that may prove difficult to delineate (Hanley *et al*., 1997). Non-use value relates to existence value, which is the value something receives purely based on the fact that the person knows it exists, without even having any intention of using it. Non-use value also includes option value, which is the value something receives based on preserving it for possible future use.

The various external costs of the livestock industry can be calculated through determining the cost of developing, replacing and maintaining necessary infrastructure and services needed to address the environmental impacts (Tegtmeier and Duffy, 2004). Moreover, a WTP survey can be used to determine the amount of value people add to a pollutant free environment or resource, such as water for example.

Polluted water can lead to various external costs, which needs to be calculated in order to fully understand the impact of the livestock industry on the environment.
The value of pollution-free water can be estimated in order to assess how much the commercial fisheries industry would benefit from it. Preservation values, which are non-user

values, can be allocated to clean water. Pollutant-free water delivers aesthetic and ecological benefits and options for future use to non-users. On the other hand, polluted water will decrease property values of waterfront properties.

Municipalities and industrial factories such as steam power plants are also burdened by higher operational costs as the water they receive is contaminated with higher volumes of minerals and salts after receiving it from water treatment plants (Tegtmeier and Duffy, 2004). The water needs to be further demineralized and treated to avoid the accumulation of algae and scale in it and also in boiling systems.

Moreover, sediment increases the turbidity in water sources and carries toxic materials, such as fertilizer and pesticide residues, downstream (Tegtmeier and Duffy, 2004). A study in the United States found that sediment resulted in 88% of nitrogen and 86% of phosphorus occurring in the country's watercourses (Holmes, 1988). The annual cost to supply water can be determined by using Holmes' method where the usage of various treatment costs is multiplied with the country's surface water extractions. The cost of the externality caused by the livestock industry can be determined by evaluating what the financial cost would be to treat and deliver the water to the public. A study should be undertaken to determine the contribution of the industry to suspended solids contaminating the country's watercourses. This percentage can then be multiplied by the financial cost of treating and delivering the water to the public to determine the financial implications the industry has to contend with regarding the water industry.

Sediment build-up further decreases the capacity of reservoirs, which is a most complex problem. Reservoirs are very unique in the sense of their site characteristics and their location. The cost to dredge the sediments from the bottom of a reservoir is extremely expensive. Moreover, it is very difficult to find licensed sites where dredged materials can be disposed of. The sediments contaminating reservoirs thus pose a big risk to our water storage capabilities. For this externality to be evaluated in monetary terms, one should look at the price it will cost to construct new reservoirs, although this may not be the most cost effective solution. The amount of water storage capacity lost per annum should be calculated, as well as the amount of sediment build-up in the reservoirs caused by the livestock industry. The

construction cost of new reservoirs should then be multiplied with the industry's sediment build-up percentage in reservoirs to provide some valuation of this problem.

Sediment blocking up roadside ditches and irrigation channels can also lead to local flooding. Maintenance is required to remove any sediment build-up to prevent this problem. The livestock industry's associated agriculture practices should be held responsible for the amount of sediment build-up they are responsible for. This percentage should be multiplied by the maintenance cost to correct and prevent this problem.

Flood damages can become more severe by an increased water volume and the settling on properties after the floodwaters have dissipated (Tegtmeier and Duffy, 2004). It is impossible to calculate the amount of damages caused by floods due to sediment and the percentage of sediment that the livestock industry is responsible for. Estimations can be calculated for the amount of damages the industry is responsible for because of soil erosion. Moreover, another estimate can be added to the equation, which is the loss of life. Various estimations for the value of life have been made. A study that reviewed 26 studies came to a value of $5.9 million per life lost (Tegtmeier and Duffy, 2004; EPA, 1999b). An in-depth study needs to be undertaken to determine how this problem can be accounted for to ensure that the damages caused by floods are accounted for by the industry.

Recreational activities taking place on and in water can be negatively impacted due to an increase in sediment in rivers, dams and lakes. For this externality to be quantified, the cost of pollution that affects recreational activities should be evaluated.

Sediments caused by erosion can accumulate in navigational channels, which can cause delays, damage to boat engines, pollution, the formation of algae and can provent the use of larger vessels. To evaluate the financial impacts this category can have, the cost to the commercial shipping industry for being grounded and for dredging should be assessed. Moreover, environmental damages and human health incidents caused by fuel or cargo spills should be assessed. Maintenance costs due to sediment accumulation in mechanical equipment can also be included in the evaluation process.

The cost to replace fish species lost can be calculated based on the cost for commercial hatching of different fish species. Fish species and aquatic environments can also be impacted through manure spills, leaks and dumping in watercourses. This external cost can be calculated by determining the number of fish killed in any such event.

The value of birds can be estimated based on their value for bird watchers, hunting costs as well as the price to hatch a bird and set it free in the wild. The external cost that the livestock industry has on birds can thus be quantified and the industry can be held responsible to at least compensate for their impact on the environment.

The excessive impact that pesticides have on the environment proves that further research on the effect of pesticides is required. In order to prevent harmful impacts caused by manure spills, farms should be regulated and inspected more often to ensure the proper disposal of manure at licensed waste disposal sites.

The monetary cost of health impact of pollutants such as pesticides can be determined in terms of production time lost. The impact can be estimated by calculating the productive time lost, which could have been used to generate income, the medical costs to treat the diseases, and in extreme cases, premature death. Other factors that should be included in the external cost are reduced quality of life and the suffering experienced by the people infected. as well as travel costs to hospitals.

It is evident that the livestock industry is responsible for more than just a handful of external costs that ultimately influences the general public. One can imagine that it is almost impossible to fully study and understand these impact to assign a monetary value to what the industry and its supporters should be responsible for. One thing is certain and that is that something, rather than nothing, should be done to investigate this monumental challenge.

3.5 Conclusion

It can thus be said that the livestock industry together with its supporting practices, mainly the agricultural industry, have a negative impact on water, air, wildlife and soil resources, as well as human health. These external costs present a financial burden, which is not covered

by the livestock industry, but is actually paid for by the general public. It is obvious that these external costs should be included in the price of meat products, which will cover the expenses that farmers have to carry to mitigate and attend to their industry's impact on the environment. The higher meat price would also discourage buyers, which would result in lower consumption of meat and thus a lower impact on the environment.

It is also evident that more scientific research is required to fully understand the different external costs caused by the livestock industry. This must include detailed studies of all the different impact categories based on their geographical regions and production types. Comparative studies should also be conducted to examine the differences between grazing and feedlot production of livestock, as well as the differences between diverse cropping and monocropping. When comparing these different production techniques, trade-offs should also be compared and evaluated. The positive externalities provided by the livestock industry and supporting practices should also be borne in mind. This will aid in the process of making policy decisions as some producers may be rewarded for such beneficial externalities.

Lastly, the Constitution of South Africa states that all citizens have the right to an environment that is not harmful to their health (South African Constitution, 1996). However, with our livestock industry becoming more intensive and posing greater environmental threats, the Constitution is being undermined.

Chapter 4: Applying ethics and philosophy to the usage of animal products

4.1 Introduction

Throughout history, humankind has been involved with liberation in one form or another. When it was not because of oppression by other tribes or nations it was from elites within one's own nation. This liberation culminated in the form of democracy. And when some thought all was well it became apparent that even in democracies all were not treated equally. The struggle for equality for women, non-Europeans, (mainly people from African descent) and most recently people with a different sexual orientation – although there is not a final solution in this regard as yet – contributed to the notion that there would be nothing else to liberate. It was thought that sexual discrimination was the final form of discrimination. However, to succumb to the notion that every possible aspect of life has been liberated, is a huge mistake as discrimination is only apparent once it is brought to the attention of those oppressed or a significant number of the privileged question the status quo.

What exactly does it mean to liberate something? According to Peter Singer (Singer, 1973, p.7) "a liberation movement demands an expansion of our moral horizons, so that practices that were previously regarded as natural and inevitable are now seen as intolerable."

Many people have their own opinions whether it is morally correct to exploit animals for the benefit of humans when it is not entirely necessary. Philosophers challenge people to think whether the use of animals for the benefit of humans are acceptable or not. A professor of Philosophy at Sussex University, Patrick Corbett, says: "…we require now to extend the great principles of liberty, equality and fraternity over the lives of animals. Let animal slavery join human slavery in the graveyard of the past." (Singer, 1973). After discussing three broad ethical issues linked to livestock production, Tom Regan's rights view and Peter Singer's utilitarian view will be discussed.

4.2.1 Unfair allocation and use of resources

The global human population is estimated to reach nine billion by the year 2050 (Henning, 2011). The human population of South Africa is also experiencing a rapid growth rate and will

reach 82 million people by 2035 (Goldblatt, 2010). In order to meet South Africans' growing demands, their food supply will have to double. Simultaneously, South Africa is experiencing an ever-expanding middle class, which results in an increase in the consumption of livestock products. Middle class populations tend to adopt a more protein-based diet and in South Africa this means moving from one largely dependent on a staple grain diet. Unfortunately, this growing demand for animal protein results in the mass production of meat, which means that animals are now being produced in "factories" instead of roaming on open pastures. The animals are fed low-value protein (soy feed) and are ultimately turned into high-value protein products (Henning, 2011). It is estimated that globally around 56 billion animals are slaughtered every year for human needs (Henning, 2011).

The livestock industry is South Africa's largest agricultural sector, with 69% of the country's land being suitable for grazing. However, as human settlements and the mining and forestry industry continue to expand, the amount of available land becomes scarcer (Goldblatt, 2010). This results in the land being used as pastures and being overstocked, and thus overgrazed, which can cause irreversible damage to the environment, through erosion and reduced soil fertility (Goldblatt, 2010).

Although land suitable for producing wheat and maize is on the decrease, its production has remained relatively consistent for the last 20 years (Goldblatt, 2010). The main reason that allows for the steady production of these grains, is intensified production methods being used, i.e. the use of fertilisers, fuel and an increase in irrigation (Goldblatt, 2010). In the past, cattle use to graze on pastures that were not necessarily suited for the production of crops. Cattle traditionally grazed on inedible grasses and not on grain as is the case nowadays (Goldblatt, 2010). It is estimated that around 75% of cattle in South Africa feed on grain and are confined to feedlots for more than 70% of their existence. This results in more than 50% of South African maize being allocated to feeding animals instead of people, of which millions are food deprived (Goldblatt, 2010).

To produce 1 kg of grain-fed beef requires around 13 kg of grain. When the amount of fertilisers and pesticides used in the process of producing beef enters the equation, it is estimated that 1 calorie of beef needs around 40 calories of fossil fuel to be produced

(Henning, 2011). It can thus be said that animals are consuming more food than what they are providing after being processed (Henning, 2011). It is estimated that the some 800 million people who face starvation each day around the world can be sufficiently fed for a year with the amount of grain fed to cattle in the United States of America every year (Henning, 2011).

In a country where poverty and starvation are clearly evident – such as South Africa – to feed animals a crop that could have been used to feed the underprivileged is an ethically significant matter. Malnourished childrens' brain development will be lower than normal, which will lead to a decrease in learning abilities during their youth and eventually a lower economic contribution during their adulthood (Akombi *et al.,* 2017). South Africa's distribution share is currently worse than during the apartheid era, which makes proper nutrition to everyone of ethical importance (Obuaku-Igwe, 2015). Proper nutrition can have a drastic impact on decreasing inequality in South Africa.

Not only does livestock consume massive amounts of food resources that could have been used to feed the malnourished, but they also expend more than 50% of the world's antibiotics supplies (Henning, 2011). This is unacceptable, as millions of people do not have the financial backing to receive medical care. The middle and upper classes overconsume meat products that are contaminated with antibiotics resulting in human infections that are strongly resistant to antibiotic treatments (Henning, 2011).

It is clear that an over consumption of livestock products has negative impacts on human health, as well as food resources that otherwise could be allocated to humans. However, as discussed in previous chapters, it also has an immense negative impact on the environment.

4.2.2 Environmental degradation and sustainability

Many regions in the world utilise freshwater resources at a far greater rate than what it can be replaced (Henning, 2011). It is not necessarily the number of people utilizing a water resource that is the problem, but rather for what the water usage is allocated to (Henning, 2011). Globally, 70% of freshwater is consumed by the agricultural industry compared to domestic use being responsible for 10% of the usage (Henning, 2011).

Moreover, it is estimated that to produce 1kg of animal protein, requires 100 times more water compared to the same amount of plant-based protein (Henning, 2011). In a country, such as South Africa, where water resources are scarce, it would appear to be immoral to allocate such a limited and vital resource to animals. This situation is made even more unjustifiable considering that the livestock industry also contributes to decreasing the quality of freshwater resources because of effluent being contaminated with pesticides and fertilisers entering watercourses and aquifers (Henning, 2011).

Goldblatt (2010) found atrazine, which is a residue of pesticides and herbicides, in more than 20% of surface water and ground water resources in South Africa's largest maize producing areas. Atrazine is known to cause various forms of cancer in humans, as well as influencing sexual maturation.

4.2.3 Animal well-being

Many animals' lives are negatively impacted because of humans' desire to eat meat. With the demand for animal products being so high, more animals are bred to meet the demand. Animals are kept in confinement before being slaughtered and are subjected to atrocious living conditions. Female pigs are kept in sow or gestation cubicles with chickens being housed in extremely cramped cages. To prevent chickens from fighting each other, their beaks are usually cut off. Chickens are then put through the traumatic experience of being hung up by their feet on a conveyor belt on which their throats will be slit. Moreover, pigs, veal and goats are tied down by their necks to minimilise movement preventing them from developing muscles.

Humans argue that the consumption of animals provides them with the necessary nutrients they require to lead a healthy life. However, it is true that humans can obtain the necessary nutrients from a plant-based diet (Jena, 2017). This poor justification to consume animal products, seems to be an excuse to hide behind the eagerness to eat meat. Others argue that because animals eat animals it should be morally acceptable for humans to consume animal products (Franklin, 1950). However, some animals are by nature engineered to be a carnivore and have no choice but to hunt other animals in order to survive. Humans have the capability to think whether their actions towards animals can be morally justified. Thus, the real

question should be whether consuming animals is a luxury or a necessity on which human life depends.

Moreover, there is the animal's welfare to consider. It is very difficult to provide a suitable definition for animal welfare as it requires studies dealing with various issues. Also, those who atempt to define animal welfare will do it based on principles they relate to. It is thus important to recognize that animal welfare comprises various factors, which include scientific, ethical and political aspects of the concept (Lund *et al.,* 2006). The scientific factors can be subdivided into three categories of ethology, physiology and psychology (Jena, 2017). Ethology entails the studying of animal behaviour which can be used to explain stress in animals (Millman *et al.,* 2004). Understanding animals on a behavioural level is of utmost importance as it can aid in stipulating specific design requirements for animal dwellings and associated necessities which will improve the living standards of the animals (Grandin, 1993). Psychology also provides important information to understanding animal emotions which contribute to animal welfare research (Desire *et al.,* 2002).

Due to the unfortunate reality that millions of South Africans do not have access to potable water and basic sanitation, the notion of using a scarce resource, such as water, to produce grain for beef that will be enjoyed by a small fraction of the population, is most definitely a moral issue. The issue becomes more complicated once the welfare of the animals is investigated.

Many moral philosophers, such as Aristotle, rejected the notion that animals had a moral standing and discounted their interests based on the mere fact that they were not human. He thus believed that animals existed for the purpose of serving man. This idea was further promoted by Aquinas who believed that humans do not owe animals any form of charity. Kant supported this belief and said that humans have no obligations towards animals. John Rawls has recently rejected the belonging of animals in his justice theory, believing that only those who understand the concept of justice is to be allowed justice, excluding human infants (Singer, 1990). In contrast, Regan and Singer's philosophical approaches will be reviewed in order to attempt to answer the question whether it is morally acceptable for humans to consume animal products.

4.3.1 Tom Regan's Rights view

Tom Regan's Rights View argues that non-human animals must enjoy a moral standing and inherent value, as they are ends in themselves. He also states that any case that is valid to defend a human's right to life can be used to defend an animal's right to life (Regan, 1984). Regan's viewpoint starts by acknowledging that humans have intrinsic value as they have a desire to reach goals, which will make their lives more valuable when achieved. Regan infers that all people have the equal right to accomplish their own life goals as long as it will not cause harm to anyone else. Due to the fact that goals cannot be accomplished when the person has passed away, all humans enjoy the same right to life (Regan, 1975).

Regan argues that the same can be said to defend the right of an animal to enjoy life. Animals that are conscious, capable of experiencing pain and pleasure, can desire something or have expectations of something and have memories are classified by Regan as a subject of a life. Once an animal is classified as a subject of a life, humans should not be allowed to kill, injure or exploit the animal as this would violate the animal's rights (Regan, 1984). Regan considers animals older than one year to be a subject of a life and thus have an inherent value (Engel, 2009; Regan, 1984). Following this notion, all humans are morally obliged not to kill or harm animals, use their bodies for human needs or impact their freedom of choice (Lotter, 2006). Thus, farming animals for products such as meat, wool and eggs would be immoral.

4.3.2 Strengths of Regan's Rights view [1]

Most people who consume livestock products argue that as long as the animals are slaughtered in a humane way which eliminates suffering, then they are fine with consuming the animal product. However, Regan's Rights view does not revolve around the idea that inflicting pain on animals is morally unacceptable, but rather the notion of humans killing the animals.

The killing of human beings could never be justified by arguing that it provides the killer with a sense of joy or an intrinsically good experience to others, as each human being has the right

[1] This section is largely based on Regan (1975)

to his/her own life. Moreover, one can also not support the argument that the human was killed without suffering pain and thus is acceptable as it is not the act of inflicting pain on others that is wrong, but rather violating that person's right to his/her life. The same rationalization can be used for animals. For Regan it is not about causing pain to innocent animals. It thus, does not make it morally justifiable to kill an animal when it is numbed to reduce its suffering as the issue is not inflicting pain on them, but rather violating the animal's right to life.

Regan argues that until such time that humans can prove that only they have an inherent equal right to life, animals should not be excluded from the current rationalization that defends humans' equal right to life. As killing human beings cannot be justified for providing pleasure to others, so can it not be justified to slaughter animals in order for a small portion of people to reap the benefits – in the form of meat or other animal products.

Regan's Rights view exposes how other arguments preserving the notion that only humans have an equal right to life, should either be rejected or the theory should be adapted to accommodate the notion that animals should also enjoy equal rights. Regan argues that if the right to life is granted based on attributes such as being reasonable, being able to make uninhibited choices and having a concept of self, then mentally handicapped people and infants should be excluded from this, so called privileged class.

In conclusion, animals cannot be stripped from the equal right of enjoying their lives if humans cannot prove that they are the only beings on earth who have a feature unique to them, which only permits them equal right to life.

4.3.3 Weaknesses of Tom Regan's Rights view

Regan conceded that under special circumstances it could be acceptable to slaughter an animal, as long as the killing is not done for the sake of providing pleasure to humans (Regan, 1975). In order for such a killing to be acceptable, it must be proved that the action would reduce or eliminate a greater negative threat and that this result can only be achieved through killing this animal. Moreover, one needs to prove that the chances are good of realizing the required results (Regan, 1975).

This exception to Regan's Rights view comes across as utilitarian from a deontological viewpoint, which makes his argument vulnerable to criticism. If it can be argued that under special occasions the slaughtering of animals is acceptable, then according to him it can also be acceptable to kill humans, if the conditions were favourable. If this is not the case, then the equality of the right to life between humans and animals would never be the same and humans would always be superior to animals in this sense. Moreover, who can decide what the conditions of approval should be to slaughter an animal, or a human for that matter?

Regan's Rights view is further complicated through not specifying which animals should be permitted to be subjects of a life. One may feel that larger animals, such as elephants, may be more intelligent and have a greater capacity to experience pleasures and discontent compared to a smaller one, such as a chicken. Moreover, no clarity is given from Regan regarding the rights of animals younger than one year. If one interprets Regan's Rights view literally, then it could be argued that eating veal is morally acceptable, but eating a cow is immoral. This would be a peculiar result for a viewpoint that aims to promote vegetarianism.

Lastly, it may be possible that no such thing as natural rights exists, which leads to the foundation of Regan's Rights view to be worthless. Regan attended to this concern by saying that his notion does not argue that humans or animals have natural rights, but rather that the argument used to explain why humans have natural rights, can also be used to argue that animals should enjoy the same natural rights (Regan, 1975). Regan admitted that if it can be proven that natural rights do not exist, then his Rights View will be diminished of its power. However, Regan stated that in the case that humans have no natural rights, they could still object to the notion of inflicting pain to animals purely for the sake of providing other humans with pleasure. Humans would be equally capable to object to causing pain on other humans for the sake of providing or experiencing pleasure (Regan, 1975).

4.4 Peter Singer's view on animal rights[2]

Peter Singer associates himself with the ethical theory of utilitarianism. One of the first philosophers who introduced the utilitarian approach was Jeremy Bentham. Bentham

[2] Section 4.4 is mostly a summary of Singer (1980).

explained the foundation of equality as: “Each to count for one and none for more than one.” (Singer, 1973; p.8). This essentially means that any being with interests deserves the same amount of consideration and treatment than any other being with interests. Utilitarianism takes into account the suffering and happiness of all humans and nonhuman animals. The theory argues that humans should morally consider nonhuman animals before taking action and that their interests deserve the same amount of moral consideration as humans. Peter Singer studied what the result would be when including the interests of nonhuman animals implied by utilitarianism.

Singer believes that by relating the principles of utility to the current methods used to breed animals for human consumption and with the availability of different food sources, humans ought to be vegetarians. Singer sees vegetarianism as a means to an end rather than an end in itself. Applying the classic form of utilitarianism on how livestock is treated, will result in reducing pain and increasing pleasure. All livestock has the capacity to experience pain and pleasure, which means that they all have the right to be morally considered. Thus, livestock can be seen as equals to humans and contrasting to a non-living entity such as a rock. Singer feels that this vital point is so obvious that one may neglect its importance. Singer’s “principle of equality” states that any being’s interests that can be affected by an action should be considered equal to the interests of any other being. Singer states that the principle of equality does not mean that every being should be treated equally, but rather considered equally (Singer, 1990).

Singer hopes that the world’s current livestock practices that give minimal consideration to the interests of the animals, will strive to do so, maximize their pleasures and minimize their pain. Singer believes that more strict rules should be applied to experiments involving animals, as well as livestock practices involving intensive farming methods, which cause unnecessary pain and stress to the animals such as pigs, veal, cows, chickens, etc. Other moral philosophers such as Regan do not wish for the same. Singer’s disagreement with Regan and other moral philosophers is not whether current methods of livestock farming and other practices involving animals are ideal according to utilitarian standards. They all agree on that notion. The disparity is whether these practices, based on utilitarian standards, implies that we should adopt vegetarian diets.

Singer recognises three ways in which the utilitarian condemnation of the treatment of livestock animals can fall short in terms of adopting a vegetarian diet. Firstly, if the objection emphasizes only the methods used to raise and slaughter the animals, then it could be possible to reject the notion of adopting a vegetarian diet and focus on only eating meat that was not raised and slaughtered through methods inflicting pain and suffering on the animal. Secondly, it could be argued that the significance of ending harmful livestock practices may not be greater than if these practices were to be continued. Lastly Singer recognizes that people who believe that it would be better to abolish harmful livestock practices can also argue that there is no utilitarian argument to support this and the responsibility of refusing to consume livestock reared through harmful farming methods.

Based on the first argument that states that a vegetarian diet is not a moral necessity when the animal eaten, lived a pleasurable life and was killed in a painless manner results in valid questions about the significance of life and the validity of seeing the next group of reared animals enjoying a pleasurable life as just substitutes for the animals that were consumed. Singer acknowledges the fact that in some cases there may not be any utilitarian protest to consume animals as a source of food, but states that this does not apply to people who make use of commercially farmed meat products (Singer, 1979). Moreover, in *Animal Liberation* (1973; p.164) Singer explains that although there may not be a direct utilitarian challenge, there will be an indirect challenge: “If we are prepared to take the life of another being merely in order to satisfy our taste for a particular type of food, then that being is no more than a means to our end.” Singer’s perception on animal rights steered Leslie Pickering Francis and Richard Norman to adopt the Kantian objection to view the use of animals as means to ends (Francis and Norman, 1978). Francis and Norman supposed that in the future we will see animals as objects for humans to exploit irrespective of our human compassion towards them. Moreover, they noted that when it is realized that in order to be capable of supplying the amount of livestock at an acceptable price, it would be acceptable to change the animals’ living conditions. As they stated: “The factory farm is nothing more than the application of technology to the idea that animals are means to our ends.” (Francis and Norman, 1978). Singer labelled this argument as a “slippery slope” arguing that irrespective of how human their original intentions were, if the consumption of meat continues then harmful livestock practices may be considered to supply the demand.

Regan insists on the second argument (p.12) that utilitarianism should not result in the adoption of a vegetarian diet. Regan believes that it is very difficult to state that the suffering caused by harmful livestock practices is greater than the pleasures enjoyed by humans consuming the meat, as well as the disruptions caused by abolishing those farming practices to the families who are dependent on this particular industry. Singer agrees that to prove this point is very difficult. However, the first step that Singer took was to shed light on how much animals suffer under current farming practices. The third chapter of his book, *Animal Liberation*, attempted to depict the horrific truths of these modern farming practices. Secondly, Singer attempted to show that adopting a vegetarian diet does not result in any health risks, nor the risk of not being able to feed the world's population, nor sacrificing the pleasures of enjoying good tastes. The third step Singer would have to consider is what the impact of the world turning vegetarian would have on the families dependent on the livestock industry. Singer did not calculate this as he is of the opinion that in the long run, the value of abolishing this industry would be outweighed by the benefits received by both humans and animals. Singer included both animals and humans because if the question is objectively assessed, then the related benefits, as well as related losses, should be included. It is a known fact that has been stated by many that a reduction in meat consumption would provide massive amounts of soybeans, grains and other plant-based products, which would have been fed to animals, to go to the millions of starving and malnourished humans. This benefit to humans alone can be argued to outweigh the related losses endured by livestock farmers. Moreover, a vegetarian diet promotes health benefits such as the decrease in the possibility of developing stomach and colon cancer, as well as heart diseases, as mentioned in Chapter 4. Lastly, as discussed in Chapter 3, the environmental impacts that are caused by livestock farming will decrease immensely.

If one only focuses on the benefits animals would receive and the losses livestock farmers would endure, it still seems that the abolishment of modern livestock farming, based on the principle of utility, would be the correct decision. Undoubtedly many people would suffer financially, but such suffering would only occur once. Thus, livestock farming would either eventually stop, which would only delay the financial suffering of farmers, or animals would continue to suffer for eternity. If the interests of animals were to receive the same consideration of those of humans, then, clearly, the once-off cost of transition to adopt a

vegetarian diet would far outweigh the eternal suffering of animals. Singer accepts that livestock farming will not disappear overnight, but the gradual abolishment of livestock farming is the way forward.

Based on the third argument on page 12, a connection should be established between the abolishment of livestock farms and becoming a vegetarian. Singer attempted to make this connection in two different ways. He resonated with the remark George Bernard Shaw made by saying that when he dies he will go to his grave followed by all the animals his vegetarian diet saved. Singer proclaimed that when one person becomes vegetarian, it brings down the demand for meat, which in turn will save the life of an animal. This notion of Singer was quickly shattered by many who informed him that when one person in a million decided to cease eating meat, it would make no difference as the production of products is based on thresholds. If the demand for a product changes within a certain threshold, no impact will be observed on its production, price or profit.

Singer admitted that his statement was wrong, but it is true that a large number of vegetarians will together make a difference. For example, for x-amount of vegetarians, x-amount of animals would be saved from a horrific unnatural life. According to utilitarianism, actions are judged by their probable consequences, thus saving 1 chicken with certainty is equal to the chance of saving one out of 10,000 chickens, given 10,000 chickens.

Secondly, Singer tried to connect a vegetarian diet to the abolishment of livestock farms by describing it as the most effective action we can take to end animal exploitation (Singer, 1990). Singer admits that this statement can also be heavily criticised as activists and people who are skilled at running campaigns to end animal exploitation may be more effective. However, Singer does not promote this form of vegetarianism. Singer promotes vegetarianism through highlighting and emphasising human activities that are impeding on the rights of animals (Singer, 1990).

Singer still believes that by becoming vegetarian it is still one of the most practical ways to bring change to the lives of animals. By changing your own personal ways, you can reply to people when they ask why you are fighting against seal clubbing, eating pigs, cows, etc. It is

necessary to make personal commitments in order to convince others to follow a vegetarian diet. Lastly Singer states: "… becoming a vegetarian is a way of attesting to the depth and sincerity of one's belief in the wrongness of what we are doing to animals." (Singer, 1980; p337).

4.5 Conclusion

Regan's Rights view argues that all humans should be morally obliged to follow a diet that excludes the consumption of any animal considered as a subject of life. However, I am of the opinion that Regan's Rights view cannot solely be used to convince an ever-increasing human population not to consume animal-based food products. The earth provides humans with a limited supply of resources and space, which can be used to sustain their livelihoods. The consumption of meat products should not only be based on whether or not it is morally acceptable, but also whether or not a global intake of this resource is sustainable or not. It is evident that at the current rate we are destroying our planet and exhausting its resources to fuel our need for meat, which only a smaller group of the human population is "privileged" enough to consume on a mass scale.

Although Regan's Rights view states that the exclusion of meat in one's diet is a moral obligation, it does not mean that it is the most sustainable diet option for humans to follow. The consumption of a purely plant-based diet requires a huge amount of fertilisers and pesticides of which the environmental impact on such a large scale is not known. It may be proved to cause as much environmental damage or even more (Henning, 2011). One can state with a certain amount of confidence, that once the production of meat or plant-based food products become mass-produced, the environmental impact would increase dramatically (Henning, 2011).

When Singer's argument is taken into consideration, philosophically it makes more sense than that of Regan's. If Regan would allow any animal younger than 1 year old to be eaten, as it has no sense in itself yet, then one could argue that a human infant of a few months old may also be killed. All living animals have their own interest and react to painful experiences. Their behavioural changes can be observed when pain is inflicted through the sounds they make or their movements. Thus, Singer's argument that all sentient beings deserve the same amount

of consideration as humans should be a given. How animals are kept in cages or in factory farms can be directly compared to how the Nazis in Germany held the Jews in death camps. Although that comparison may seem a bit excessive, when Singer's view of animal rights is applied, then it is the perfect comparison to make. The world is at a stage where we ought not to discriminate against race, religion and sexual orientation. With the vast amount of knowledge and data freely available to the world, as well as scientific research indicating that plant-based diets are sufficient in supplying the nutritional value needed for humans, one could expect/hope that the era of exploiting animals purely for the sake of taste, will soon also be taboo.

Although I question how humans can dictate other sentient beings' existence on our planet, we should view humans as part of the food chain. Humans are in the position to be one of the most advanced thinking organisms on this planet, or so we think. Just as sharks prey on fish, and game fish prey on smaller fish, etc. so do we humans prey on animals that are not capable of outsmarting us. At the end of the day it all comes down to survival. However, based on the fact that humans don't require animal meat to survive, we should be the ones speaking out for those who cannot. Just as we would protect an infant human from being harmed, so should we stand up against the suffering of other sentient beings. Humans do have the option to survive and thrive following a purely plant-based diet, but why would we wish to do that if we can have a diet based on various forms of protein? The morality of our choice of diet should rather be based on whether a sentient being suffered for one's one selfish pleasures, rather than whether the chicken was a free-range chicken or not. Without making radical changes in our diets we can still enjoy tasteful dishes whilst lowering our environmental footprint through making conscious decisions on what we eat.

Thus, with that being said and considering the philosophers' theories, I hold the opinion that humans should make the "drastic" decision of being conscious consumers and switching to a meat free diet. As mentioned before, humans can easily be provided with the nutrients needed by eating plant-based meals. It is understandable that the change in diet won't happen overnight (unless one actually visits factory farms or watches documentaries about the issue), but to gradually phase out meat is something any person can achieve. Livestock should be treated with the same respect as humans and be allowed to live their lives till an

old age. Humans have no right to dictate the path their lives should follow. Animals most definitely have a sense of compassion and although we cannot physically prove it or talk to them to confirm it, we should grant them the courtesy to live out their natural lives in a comfortable environment.

Finally, humans should not consider themselves as the apex predators in this world. If humans continue with their current destructive lifestyles, they will be their own worst enemy causing humankind to come under serious threat and eventual extinction.

Chapter 5: Alternative protein source [3]

5.1 A brief history of entomophagy[4]

Although meat is the most general source of protein for human consumption, various other forms of protein do exist, which can act as a substitute for the resource intensive production of meat. The most conventional protein alternatives to meat are soy and plant based products. Just like the conventional form of livestock, such as cattle, more unconventional forms of 'mini-livestock', such as insects, are available for humans to breed with and consume (Premalatha et al., 2011). The focus of this chapter will solely be placed on insects as it is the least discussed meat substitute in the western world that holds endless possibilities with a very low environmental footprint compared to other more conventional meat alternatives on the market (Smetana *et al.,* 2015). Furthermore, most philosophers exclude insects from having a moral standing due to the absence of a central nervous system (Lamey, 2007). Tom Regan admits that he does not know whether insects are sentient stating that accurate conclusions cannot be made for animal consciousness based on animal behaviour (Dresser, 1983).

Millions of years ago, minil-ivestock made up a substantial part of human diets and had the ability to provide animal protein, of which there is a critical shortage today (Pimentel and Pimentel, 2003, 2008). The human consumption of insects, also known as 'entomophagy', may sound revolting, but it has been part of the human diet for millions of years (DeFoliart, 1999). Fossilised human feces and archeological evidence prove that humans have evolved as consumers of insects (Ramons-Elorduy, 2009). Pre-historic humans mostly enjoyed termites as a protein source. Evidence also suggests that the Australopithecus robustus, which is an ancestor of the Homo sapiens, made use of bones to harvest termites (Van Huis, 2003). Moreover, evidence suggests that the nutrients obtained from consuming insects, may have aided in the development of the human brain (Fontaneto et al., 2011). The Paranthropus and Australopithecus' dental enamel both had high

[3] Brief summary of Asgar, M.A., Fazilah, A., Huda, N., Bhat, R. and Karim, A.A. 2010. Nonmeat protein alternatives as meat extenders and meat analogs. Comprehensive Reviews in Food Science and Food Safety 9: 513 – 529.

[4] Overview of Tabassum, A., Abbasi, T. and Abbasi, S.A. 2016. Reducing the global environmental impact of livestock production: the mini-livestock option. Journal of Cleaner Production 112: 1754 – 1766.

ratios of 13C/12C and Sr/Ca, which indicate a diet of the pre-historic humankind containing high volumes of insects (Mlcek et al., 2014). More recent examples of civilizations practicing entomophagy include the Greeks, Romans, Aztecs and Egyptians (Bodenheimer, 1951; Premalatha et al., 2011; Van Itterbeeck and Van Huis, 2012). Even today cheese maggots are regarded as a delicacy in Italy and Croatia (Overstreet, 2003). Entomophagy is commonly practiced in the Americas, Africa and southeast Asia, where more than 1 700 insect species are consumed on a daily basis (Raubenheimer and Rothman, 2013). An inventory of edible insects was set up and included 2,163 species (Jongema, 2012). Although most people may regard insects as a food option for poor populations, some of the most expensive food in Australia, Japan and China is based on insects (Paoletti and Dreon, 2005).

It is proposed that during the last 3500 years as organized religions started, the use of insects as a food source began to decline (Premalatha et al., 2011; Van Huis, 2013). Believers in some religions were told to only consume certain types of white and red meats (excluding insects), while in other religions the consumption of any animal protein was not allowed. There is evidence of entomophagy (especially locusts) in Christian, Islamic and Jewish literature, however, most emphasis is placed on macrolivestock and thus the consumption of insects by these believers declined (Van Huis, 2013). As Asia, Africa and the Americas became colonized by the Europeans, who weren't consuming insects, these regions' habits of consuming insects also faded (Ramos-Elorduy, 2009). The globalization of the fast-food culture resulted in many third-world country inhabitants turning away from consuming insects (Obopile and Seeletso, 2013). Many people who are still consuming insects are reluctant to do so in public as they may be seen as 'uncivilised' (Meyer-Rochow and Chakravorty, 2013). It is ironic to see how the avoidance of consuming insects is irrational as most people thrive on honey, which is principally bee vomit (Tabassum et al., 2016). Moreover, usual macrolivestock meat products can result in life-threatening diseases and can cause gastero-intestinal problems, but are still generally seen as a 'safe' and 'clean' source of protein, whilst at the same time insects are labelled as a dirty and unsafe source of protein for no legitimate reason. The general attitude toward consuming insects can be blamed on opinion-makers in the so-called advanced Western countries, where the consumption of insects is usually treated with utter disgust. Moreover, insects are usually pictured as horrific creatures that will harm humans in most commercial films. It is thus believed that by indoctrinating global society with Western beliefes and culture, drove most people away from consuming insects (Belluco et al.,

2013). What remains a mystery is how Western society has become reluctant to consuming insects (Looy et al., 2013). Entomophagous people also experience all the aspects of insects that ause disgust with Westerners, but they have overcome those elements. It is interesting to note that various Western authors have tried to promote entomophagy (Howard, 1916). During the food shortage experienced after World War 1, Howard attempted to attract people to entomophagy by showing them how to prepare and eat insect-based dishes (Shockley and Dossey, 2014). However, his and several others' attempts to attract people to entomophagy could not overcome Westerners' strong disgust towards insects. By excluding insects from their diets and relying mostly on conventional macrolivestock protein sources, the global food availability has been adversely impacted whilst endangering the earth's ecosystem as and most possibly their own health (Tabassum et al., 2016).

Although entomophagy is generally practiced by the poor, in Australia, Europe, northeast India and Southeast Asia various insect species are valuable and are an integral part in various elite dishes (DeFoliart, 1999; Van Huis, 2013). Various species of wasps, locusts, caterpillars and crickets are considered as delicacies in Thai restaurants. In some African countries, termite queens are considered to be a delicacy and are prepared on special occasions (Owen, 1973). In Japan, the annual sale of ants is estimated to be around $100 million. In Pakistan and in Arabian countries, locusts are known as 'aerial shrimps' and are served with relish (DeFoliart, 2002). In northeast India, silkworms are more generally consumed as food rather than used to produce silk (Sarmah, 2011).

Although it is thought that Western influence has decreased the practice of entomophagy, it can now be said that the same influence is now stimulating the movement (Bednarova et al., 2013, 2014; Megido and Sablon, 2014). Various entomophagy cooking books and books have recently been published to promote entomophagy (Shockley and Dossey, 2014). Market research has been conducted in recent times in order to identify promotion strategies for entomophagy (Megido and Sablon, 2014; Mlcek et al., 2014).

5.2 Advantages of insects as human food

The farming and consumption of insects as an alternative food source for humans have various advantages when compared to more conventional livestock.

5.2.1 Cleaner source of food

Generally, humans have the misperception that harvested insects from nature are unhygienic, but that the raising of chicken, goats, lobsters, etc., even without quality control, is 'cleaner' (Martins and Pliner, 2005; Van Huis, 2013). The majority of people thus think that the meat from an insect is dirtier than that of free foraging livestock. The truth of the matter is actually that that perception is false. Many insect species are herbivores and graze only on a selected few plant species and avoid polluted areas. In this regard it can thus be said that these insect species have more hygienic and healthier living standards, compared to those of the more conventional livestock humans consume (Bukkens, 1997). It goes without saying that insect meat is not more likely to be more contaminated than that of more conventional livestock meat – actually it would be cleaner. Grasshoppers are considered to be one of the cleanest animals due to their strict plant-based diet (Holt, 1988). Grasshopper-fed chickens are considered to be tastier than chickens on conventional food and reach a higher price (DeFoliart, 1997). As previously mentioned, various insect species are strict herbivores and only graze on specific plant species. This makes it much easier to control the diet of the insect, compared to the less selective conventional livestock species such as chicken and lobster. By controlling the diet of insects, it is possible to control the quality of protein they provide, which is much more difficult with farmed macrolivestock (Tabassum et al., 2016).

5.2.2 Greater energy efficiency

Insects generate more protein per kilogram of vegetation consumed, compared to conventional livestock (Gullan and Cranston, 2005; Van Huis, 2013). Enormous amounts of energy are required to produce meat products. It is estimated that meat production requires 10 times the amount of plant nutrients than to produce the same amount of insect protein (Nakagaki and DeFoliart, 1991; Smil, 2002). Insects have the ability to convert phytomass into zoomass at a much more efficient rate than conventional livestock (Nakagaki and DeFoliart, 1991). Insects have high edible weight fractions, which make farming and consuming them much less energy intensive. Crickets, for example, are 80% edible compared to chicken, which are 58% and beef 40% (Nakagaki and DeFoliart, 1991; Van Huis, 2013).

Moreover, insects can alter their body temperatures to suit that of their immediate surrounding, making them poikilothermic. This allows insects to spend less energy and nutrients on altering their

body temperatures compared to warm-blooded livestock (Lindroth, 1993; Oonincx et al., 2010). For these reasons insect-based production for protein is much more energy efficient.

5.2.3 Greater fecundity

Insects reach maturity much faster and reproduce faster than conventional livestock. Insects reproduce thousands of offspring, whilst conventional livestock only produce a few. For example, chickens require several months and rumens several years before they reach maturity, while insects mature within days. The quick lifespan and mass reproductions of insects thus allow a much higher rate of protein production compared to conventional livestock (Tabassum-Abbasi et al., 2016).

5.2.4 Greater diversity

Insect diversity is much greater compared to mammals and poultry. The class of Insecta is the largest animal group in the world and has more species than all other animal classes combined (Tabassum-Abbasi et al., 2016). It is estimated that 80% of the animal kingdom comprises insects with more than a million species known to exist (Capinera, 2008). Due to the sheer number of insects, the choice of edible insects is exceptionally broad. Moreover, every region in the world contains its endemic insects, which all graze on the vegetation in the area. This makes it possible to produce insect-based protein with much less stress on biodiversity. Compared to a few dozen edible species of higher animals, it is estimated that more than 2 000 edible insect species have been classified, with many more still to be approved (Heinrich and Prieto, 2008; Jongema, 2012; Rumpold and Schluter, 2013a). The pressure on the natural populations and biodiversity of insect species can be further relieved through semi-domesticating the desired insect species (Paoletti and Dreon, 2005).

5.2.5 Smaller production areas required

Conventional livestock requires large areas on which to be farmed. In contrast, much smaller areas are required to reproduce insects. For example, insects can be domestically reared in small areas not larger than what a normal fridge would take up. For the large-scale production of insects, mechanised facilities can and are constructed. But generally, insect farming occurs in backyards by using inexpensive materials (Van Huis, 2013). For the production of crickets, people usually make

use of concrete rings that are 0.5m high and 0.8m wide, or plastic bowls. Rice is placed in the bottom of the container. Grasses, poultry feed, and vegetable and flower waster are used to nurture the produce (Yhoung-Aree and Viwatpanich, 2005; Van Huis, 2013).

A study was done to calculate the size of land required to produce insect protein (mealworm) over its lifespan in comparison to the same amount of protein derived from milk, chicken, pork and beef (Oonincx and De Boer, 2012). The results indicated that for every 1-hectare of land needed to produce mealworm protein, the production of milk, pork/chicken and beef protein required 2.5, 2 – 3.5, and 10 ha respectively. Understandably these figures will vary based on the type of insect species being examined. However, it does present an indication that conventional livestock protein requires much more land compared to insect-based protein produce.

5.2.6 Saving grain whilst facilitating pollution control

One of the major advantages of farming with insects is that they can feed on almost any biodegradable waste substance (Tabassum et al., 2016). It has been found that almost every biodegradable substance can be eaten by one or more insect species (DeFoliart, 1989). Insects feeding on organic waste, such as manure, may be vulnerable to be contaminated by pathogens and thus not fit for human consumption. However, these insects can still be utilised to serve as a food source for poultry or fish, eliminating the need for grain as a feedcrop for livestock, which could now be used for human consumption. This substitution of grain can be supported by the fact that 60% of the cost to rear farm animals comprises the feedcrop the animals receive, of which grain makes up a substantial amount. It is estimated that every year in the USA around 91% of the 27.1 million tons of vegetable protein, cereal and legumes, which is suitable for human consumption, is fed to livestock. From that amount of feed, only 5.3million tons of animal protein is produced (Pimental et al., 1975). Moreover, various studies have indicated that the use of insects as feed for chicken and fish is good, or even better, than conventional feedcrops (Ramos Elorduy et al., 2002; Ijaiya and Bko, 2009; Das et al., 2010; Halder, 2012).

Insects that exclusively graze on leaf litter and invasive plants can be raised primarily for human consumption (Abbasi and Nipaney, 1986). This further decreases the need for foodgrain to produce animal protein. Moreover, by utilizing mini-livestock as a protein source for humans, pollution control and the protection of the environment are promoted through utilizing biodegradable waste

of which the biomass includes invasive plants that have outcompeted indigenous vegetation (Abbasi and Abbasi, 2010b). If this biodegradable waste is not utilised, it will consume great amounts of resources to be treated, or, if nothing is done with it, it will pollute the surrounding environment.

Black soldier fly (Hermetia illucens) larvae is used to feed on animal manure. This is a great example where pollution is controlled through making use of bio-waste as insect feed. Not only are the nutrients in the biowaste converted into much more valuable zoomass, but it also reduces the volume of the waste, thus reducing the cost to transport it and finally its carbon footprint (Tomberlin and Sheppard, 2001; Sheppard et al., 2008). The intestines of fish are used in rearing black soldier fly larvae (St-Hilaire et al., 2007), which stimulates growth in fish, pigs and chicks (Pimentel et al., 2004; Sheppard et al., 2008). Similarly, mealworms have been reared on waste products with little nutritional value, which then serve as a growth-stimulating food source for broiler chicken (Ramos Elorduy et al., 2002).

5.2.7 Decrease in greenhouse gas (GHG) emissions

Farming with insects indirectly relieves some strain on global warming, as well as producing less GHG emissions compared to what conventional livestock produces. A recent study compared the GHG emissions of five insect species to those of pigs and ruminants. Oonincx et al. (2010) found that four out of the five studied subjects produced much smaller amounts of GHG emissions compared to the pigs and ruminants. Their results indicated that the carbon dioxide per kilogram of body mass gain (BMG) of insects (337 g/Kg) can be 39% of the amount of carbon dioxide produced per Kg BMG of pigs and 12% compared to cattle. Moreover, the average daily mass gain (ADMG) of the studied insects, which is an indication of livestock's protein production efficiency, was 25% more than that of pigs and 600% more than the ADMG of cattle. The studied insect species also produced less NH3 (3.0 – 5.4mg/kg BM/day) pound-for-pound compared to that of conventional livestock. Pigs produce 8 – 12 times the amount of NH3 than crickets and 50 times more than locusts (Oonincx et al., 2010; Oonincx and De Boer, 2012).

Oonincx, et al., (2010) reported that insects thus have a higher relative growth rate and produced less GHG and NH3 emissions compared to conventional livestock. An additional study investigated mealworm production's land use, global warming potential and energy use, and compared the

quantities with similar quantities of milk, beef, chicken and pork production (Oonincx and De Boer, 2012). The results indicated that the footprint of milk and chicken production is twice the amount of that of mealworms with pork and beef production having even larger footprints. The quantity of water used to produce mealworms is also lower compared to the production of beef, chicken, pork and milk (refer to Table 5.1 below) (Chapagain and Hoeckstra, 2003). Organic waste can be used as feed to further reduce the environmental impacts of producing mealworms as feed containing mixed grains and carrot was used to produce the mealworms.

Table 5.1- Comparing conventional protein sources with the production of mealworms, in terms of resources used and its global warming potential (GWP) (Chapagain and Hoeckstra, 2003).

Protein source	*Energy (MJ/Kg edible protein)*	*Land m^2/kg edible protein)*[1]	*Water (L/kg live weight)*[2]	*GWP (kg CO_2.eq/kg edible protein)*
Mealworms reared with mixed grains and carrot	173	18	--	14
Mealworms reared without energy inputs and on organic waste	0.29	0.04	2.5[1]	0.06
Beef	177-273	142-254	9,700	77-175
Pork	95-237	46-63	2,800	21-54
Chicken	80-152	41-51	1,500	19-37
Milk	36-144	33-58	800	25-39

5.2.8 Better nutritional value

In a study where 249 edible insect species from 9 different orders were examined, it was found that 83% of the studied insects had a protein content that was 40% of their body weight and 43% had a protein content that was more than 60% of their body weight (Rumpold and Schluter, 2013a). Moreover, 72% of the species had high lipid content, with their bodies comprised of more than 40% lipids (Fig 6b). Almost a third of the 249 edible species had 30% or more of both lipids and proteins. A study conducted by Ramos Elorduy and Pino (1990) investigated 94 commonly consumed insect species and found that more than 50% had a higher caloric value than soybeans;

63% were better than beef, 87% were better than maize; and 70% were superior to beans, fish and lentils. Of the 94 species studied, only 9 species contained less than 30% protein. These results indicate that insects usually have exceptional high levels of proteins and fats, which are above that of conventional protein sources such as nuts, dairy products and meat (Tabassum et al., 2016).

Insect-based protein has the advantage of being extremely abundant and high in quality (DeFoliart, 2002). Moreover, insects comprise good proportions of all the vital amino acids and this is absorbed more easily by the consumer than compared to that of macrolivestock protein (Chen et al., 2008). For example, between 82% to 90% of termite and grasshopper protein can be digested easily, and the cholesterol intake is very low (Ritter, 1990; Ekpo et al., 2009). After removing the exoskeleton of an insect, its digestibility of its protein is even higher compared to most proteins consumed from vegetables (Finke, 2004). Protein-purine ratios in various insects, such as mealworms and super worms, are very high, which makes it appropriate for patients suffering from gout and hyperuricemia to consume (Bednarova et al., 2014).

Generally, edible insects and species within the Orthoptera order have high protein content (Rumpold and Schluter, 2013a). The nutrient quality of insect protein can be enhanced by minimizing the amount of chitin in the insect (Tabassum et al., 2016). The World Health Organisation (WHO) has determined a standard for the required essential amino acids, which is provided by most edible insects (World Health Organisation (WHO), 2007). Insects' fatty acids content is usually compared to that of fish and poultry in the sense that both are exceptionally unsaturated; however, insects do have a higher content of polyunsaturated fatty acids (PUFA) (Defoliart, 1991). Beef and pork, on the other hand, contain a very small amount of PUFA, but their fatty acid content is mostly the less desirable monosaturated fatty acids (MUFA) (Tabassum et al., 2016). Cricket and scarab beetles are believed to have an optimal fatty acid ratio for a sufficient uptake of fat being 1:1:1 (PUFA: MUFA: SFA) (Yhoung-aree et al., 2010). Usually the normal ratio of SFA to UFA in insects is 0.43 – 0.79, indicating the dominance of unsaturated acids in the fatty acid spectra of edible insects, thus augmenting the nutritional value of insects (Rumpold and Schluter, 2013a).

Generally insects have high mineral and vitamin values. However, as with other food sources, the mineral and vitamin values vary between insect species – thus, to obtain the necessary nutritional

values from insects, certain combinations must be consumed (Banjo et al., 2006; Cerritos, 2009; Rumpold and Schluter, 2013a). Christensen et al. (2006) suggests that insect-based foods provide a higher natural availability of iron, zinc and other metals compared to plants even though insects do not usually have high calcium and potassium values (Rumpold and Schluter, 2013a). Moreover, various insects provide some of the required polysaturated fatty acids that macrolivestock is not able to deliver (Fontaneto et al., 2011). The feed that insects receives determines the insect's nutrient content, which makes it possible to alter the zoomass of the insect to fit specific dietary demands from humans, i.e. diets based on low sodium and cholesterol values (Ritter, 1990; Penino et al., 1991; Ekpo et al., 2009). Some evidence suggests that in some areas where people went from entomophagy to consuming more 'modern' foods, a decrease in the health of the human population was noted (Ramos Elorduy, 1997). Due to the fact that most insects have the same high protein values as beef and a reduced fat content, it can be said that entomophagy may reduce obesity whilst still providing sufficient protein.

5.3 Insect farming

The unsustainable harvesting of insect species from nature will have the same damaging impact as overfishing has on biodiversity and habitat loss (Scahbel, 2010). It is thus vital that insect farming is practiced in such a way to promote the sustainable use of insects for human consumption. Various insect species have – since ancient times – been domestically reared for different human benefits, which include consumption. Honeybees and silkworms are good examples being used for mainly the production of wax, honey and silk, and as a food source (Bodenheimer, 1951). For other beneficial uses, cochineal (Dactylopius coccus) has been farmed for the red dye it naturally produces (Aldma-Aguilera et al., 2005). It has been estimated that insects have been farmed for specific benefits through selectively altering their environments to produce what is desired (Van Itterbeeck and Van Huis, 2012). Van Itterbeeck and Van Huis (2012) provided three examples of such cases: (a) artificial oviposition sites were constructed in Mexican lakes to harvest eggs from aquatic hemipterans; (b) in sub-Saharan Africa the positioning and abundance of host trees have been controlled – factors such as varying cultivation, making use of fire regimes, managing host tree preservation, and the introduction of caterpillars to certain areas, were used to stimulate tree living and leaf consuming caterpillars; (c) in the tropics palm trees are intentionally cut to initiate palm weevils (Rhynchophorus spp.) to lay their eggs. In Thailand maize is planted to draw locusts in to feed – they are then collected for humans to consume (Hanboonsong, 2010).

More recently various insect species have been farmed for human consumption, such as house crickets, Thailand's giant water bug and palm weevil and China's water beetles (Jach, 2003; Van Huis, 2013). When combining the total yield of several domestic facilities, the total amounts to quite a large figure. For example, two villages in Thailand comprising 400 insect farm families, produce around 10 metric tons of crickets during the production season of which a portion is exported (Johnson, 2010).

The mass production of insect farming has generally been more for producing feed for livestock or pest control (Singh, 1994). Rumpold and Schluter (2013b) wrote a paper based on previous attempts by Kok (1983), Kok et al. (1988), Sileshi and Kenis (2010) and Klunder et al. (2012) to research what is required to produce and process insects for entomophagy – this is detailed in section 7.

5.4 How safe is entomophagy?

Many fear insects, in particular the mosquito, as they play host to various diseases. Insects cause harm to humans through painful bites or through emitting powerful chemicals. How can these feared and pain inflicting animals be considered as a safe food source for human consumption? Indeed, out of the million plus insect species, some are not fit for human consumption. For this reason, as soon as a new species is discovered it must first be vigorously studied prior to adding it to the human food menu. The safety records of insect species that are currently consumed by humans are on par, or even better than those of more conventional food sources. Compared to the deadly bird-flu virus, no insect has conveyed a virus of similar intensity. Moreover, no cases have occurred where entomophagy has resulted in food poisoning compared to those involving conventional food sources (Tabassum et al., 2016). Although insects can transmit zoonotic agents such as fungi, bacteria, parasites and viruses if the insects are not prepared in a hygienic manner, no diseases comparable to the distribution and severity of influenza A, bovine tuberculosis or salmonellosis have occurred (Kruse et al., 2004; Rumpold and Schluter, 2013b). Some people do respond with allergic reactions to certain insect species when consumed, but the same happens with some people when consuming more conventional food sources. About 90% of allergic reactions caused by food consumption are triggered by eight widely consumed food sources, which include: wheat, soya, eggs, milk, fish, peanuts, shellfish and tree nuts (Pereira et al., 2005; Venter

et al., 2008). Every year one of these eight food sources are the direct cause of about 30,000 anaphylactic reactions and over 200 deaths in the USA alone (Yocum et al., 1999; Cianferoni and Spergel, 2009). Anaphylactic reactions can result in breathing troubles, a decrease in blood pressure, swelling of the mouth and throat, inducing unconsciousness, and, if not treated, possibly death (Sampson et al., 1992). One of these eight food sources causes allergic reactions in 5% of the world's population (Belluco et al., 2013). It is thus believed that entomophagy does not pose a bigger threat to human health compared to the consumption of more conventional food sources (Rumpold and Schluter, 2013a; Van Huis, 2013). Moreover, it has also been found that with regards to antinutrients, insects can be compared with more conventional food sources, which is generally considered to be healthier than insect-based food sources (Kiatbenjakul et al., 2015; Tang et al., 2015).

5.5 Potential challenges facing the establishment of an entomophagy industry

The resurgence of entomophagy has the potential to increase the desired animal protein humans require at a far smaller environmental impact than that compared to the more traditional protein food sources. Insects' ability to transform various forms of waste into usable feed can help in controlling pollution. However, the question that needs to be asked is, what are the chances of entomophagy being implemented on such a large scale to have an impact? Currently there are various indicators suggesting that a move towards large-scale entomophagy is favourable; however, there are limited quantitative data sets available to support this suggestion.

5.5.1 Challenges of mass-producing insects for human consumption

The expertise to mass-produce insects for human consumption and/or as a biological control measure for pests already exists (Paoletti and Dreon, 2005; Hwangbo et al., 2009; Van Huis, 2013). Japan has a facility that produces around 6 million melon fly (Bactrocera cucurbitae) larvae per day (Mitsuhashi, 2005). The facility plant is mostly automated and consists of a centralized control system, operating in the same manner as other complex food industries. In the Netherlands a facility produces around 100 000 kilograms per year of mealworms in an area not larger than 588m^2 (Oonincx and De Boer, 2012). A mix of grains and carrots is used as feed and is grown off site. In the USA the top 10 cricket producers produce a grand total of 2 billion crickets per year, which converts to approximately 1.36 million kg of zoomass (Tabassum et al., 2016). It is estimated that

approximately the same quantity of feeder mealworms is produced annually in the USA (Shokley and Dossey, 2014). Smaller companies around the world produce millions of additional insects annually. For decades insects have been produced on a massive scale to serve as biological control measures or pollinators, such as bees and bumblebees. In 1936 the first factory was constructed to produce screwworm on a mass scale that was fed an artificial diet (Tabassum et al., 2016). Since 1936 extensive knowledge and experience have been gained in mass-producing insects with artificial diets for biological weapons purposes (Singh, 1994; Rumpold and Schluter, 2013b). Moreover, insects have been cultivated with the aim of producing pathogenic nematodes and viruses within other living organisms (Van Huis, 2013).

It is evident from the abovementioned activities that the challenges faced by mass-producing insects are no greater than those faced by more conventional food production industries. The two major concerns are the biological contamination, specifically by disease vectors that can cause the product to become infested, and the contamination of chemicals that can cause major health risks to the consumers (Klunder et al., 2012). If any of these impacts are to materialize, it can cause major consequences as seen before in the case of the Dutch company, Kreca, which produced crickets (A. domesticus) on a mass scale. During 2000, the company suffered a loss of 50% of its cricket population because of a suspected densovirus attack. Due to the fact that Kreca only produced one species, it was vulnerable to mass fatality events – as all monocultures are. Currently, Kreca is rearing three different types of cricket species in order to be less vulnerable to a single population crash as the one experienced in 2000 (Van Huis, 2013).

Although insects are also susceptible to being infected with pathogens, these pathogens are taxonomically isolated from those associated with vertebrates and are usually not a threat to humans or macrolivestock (Jensen et al., 1977; Vega and Kaya, 2012). However, during handling and storage insect flesh is susceptible to being infected by pathogens, which can pose the same threat to humans as infected macrolivestock meat does (Banjo et al., 2006; Klunder et al., 2012). Fortunately this risk can be minimized through simple and inexpensive preservation methods (Klunder et al., 2012).

It is estimated that around 30.2 million kilograms of mealworms per day will be sufficient to eradicate the 67.6 billion Kcal/day of energy required by the world's malnourished (Nadeau et al.,

2014; FAO, 2014a, b). Moreover, if only 50% of the 30.2 million kilograms of produced mealworms can be accomplished by utilizing organic waste as feed, then some 1600ha (0.0003% of the world's 5 billion hectares of agricultural land) would be required to meet the energy demand of the world's starving population (Tabassum et al., 2016).

It is important to note that although the mass production of insects as a food source may not be more dangerous than the rearing of conventional macrolivestock, large capital investments will be required as the process of raising, cultivating and processing insects are unique compared to that of the macrolivestock industry.

5.5.2 Regulations needed to control the quality of insect-based food

Currently no regulations or standards are in place to determine and monitor the quality of insect-based foods (Tabassum et al., 2016). The few regulations that currently exist only provide information based on a few insect species that are allowed in grains and other food items. If entomophagy is to progress, then strict standards and monitoring programmes will need to be developed and implemented.

5.5.3 Protecting insects against the unsustainable harvesting from the wild

In order to encourage entomophagy, the unsustainable harvesting of insects from the wild will need to be addressed. In certain areas where entomophagy is a general practice, the uncontrolled excessive harvesting of certain insect species has placed them under threat (Ramos Elorduy, 2006). Unscrupulous gatherers have been reported cutting down trees in order to collect certain insect species more easily – not being concerned about the integrity of the surrounding environment (Vantomme et al., 2004; Dzerefos et al., 2013).

Insects provide vital ecosystem services on a daily basis. They contribute through pollinating plants, acting as scavengers, controlling pests, providing protection against wildfires and working the soil (Tabassum et al., 2016). A study estimated that four of the ecosystem services provided by insects in the USA, which are burying dung, controlling pests, acting as wildlife nutrition and pollinators, amounted to over $60 billion per annum (Losey and Vaughan, 2006). It is estimated that the economic value that ants and termites provide through processing and revitalizing soils, would be

much higher (Premalatha et al., 2011) and the same can be said for many other insect species. It is thus of vital importance that the harvesting of insects in the wild does not exceed their ability to regenerate.

The harvesting of insects from the wild can interfere with – and even worsen – the outcomes of natural predation, which may threaten population viability (Choo, 2008). The decreased insect population will thus have an impact on the species' predators. Consequently, as insect species decrease, other insect species, their predators and prey may experience cascading effects, which will impact the functioning of an entire ecosystem (Tabassum et al., 2016). Incorrect harvesting methods can also threaten the stability and regeneration abilities of insect populations (Latham, 2003; Illgner and Nel, 2000; Ramos Elorduy, 2006). Insect populations can suffer a dramatic decrease in numbers if, for example, mature insects are harvested before they mate or lay eggs (Cerritos, 2009). Due to insect populations already being pressured by habitat destruction, pollution and the use of pesticides, it is vitally important to prevent uncontrolled harvesting of insects (Morris, 2004; Losey and Vaughan, 2006). The distribution and richness of insect populations are directly influenced by these anthropogenic impacts (FAO, 2011).

In the past, before modern times, the harvesting of insects was based on traditional knowledge (Tabassum et al., 2016). People use to rely on food sources that were available in close proximity to their homes, thus harvesting of food resources, and insects, was done whilst ensuring sufficient time for the food sources to regenerate thus allowing a sustainable harvest. Traditional practices have now mostly been discarded and frequently the unselective harvesting of insects occurs, which is unsustainable (Choo, 2008, Chakravorty et al., 2013).

The controlled harvesting of insect species can be immensely beneficial. If, for example, harvesting efforts are focused on insect species that threaten agricultural crops, the need for spraying pesticides can be eliminated, whilst providing much needed protein to humans. Through making use of such a selective harvesting method, the benefits from the crops will be enhanced. A study estimates that a farmer can gain three times the amount of value from a field of corn should he choose to harvest and sell the grasshoppers that infest his crop instead of spraying them with pesticide (De Foliart, 1997). Most unwanted insect species can be controlled through harvesting

them, saving money on spraying pesticides and preventing their harmful impact on the environment.

5.5.4 Measures to be taken when consuming possible toxic insects

Regularly human consumed insect species include the stinkbug (Encosternum delegorguei), which defends itself through releasing a strong fluid and flying into the eyes of the predator (Dzerefos et al., 2013). Various other insects, such as Zonocerus veviegatus, either release chemicals or contain it in certain body parts, which will poison the consumer (Tabassum et al., 2016). Different precautionary measures to reduce the risk of toxicity when eating or cooking insects are available, but without the necessary measures in place or due to ignorance, people may be subject to harm (Barreteau, 1999; Morris, 2004; Zagrobelny et al., 2009). The consequences can be severe such as in the case when the hair of caterpillars is not burned before being consumed the toxicity can be substantial (Muyay, 1981). Surgery may be required when scarab beetles are consumed in high volumes. This is due to the beetle's indigestible chitinous remains, which can collect within human intestines causing severe constipation (Kuyten, 1960). It should be borne in mind that the consumption of conventional macrolivestock also poses significant risks to human health. Painful and devastating diseases can be the result of consuming red or white meat (conventional macrolivestock meat) that is infected with xenobiotics or pathogenic organisms (Zagrobelny et al., 2013). Although insects also accumulate heavy metals and pesticides, macrolivestock, being higher in the food chain, generally has a greater risk of containing higher concentrations (Tabassum-Abbasi et al., 2016). Consuming significant amounts of contaminated insect species will result in adverse impacts, but when consumed in moderation, these components can be beneficial to the health of the consumer. For example, the human immune system can be improved through ingesting insect-based chitin (Muzzarelli, 2010).

5.5.5 Overcoming food taboos

The taste of a food source is based on the consumer's perception of the source rather than the characteristics of the substance. What some people might find enjoyable, others may find revolting. A person's perception is influenced and shaped by her/his culture and way of life. The consumption of raw fish, as sushi, would have been considered to be uncivilized in most parts of the world a few decades ago. Sushi is now appreciated as a delicacy around the world. Most people will consider

an insect's vomit as revolting, however many enjoy honey, which, as previously mentioned, is basically a bee's vomit.

It can be said that most food taboos are irrational and that once the majority of people can acknowledge the benefits of consuming insects, the world's perception on entomophagy may change for the better. It is believed that deliberately promoting entomophagy can result in the public's perception changing for the better on the consumption of insects (Bednarova et al., 2013; Medigo et al., 2014).

5.6 Conclusion

The production of macrolivestock for human consumption is considered to be one of the largest anthropogenic contributions to global warming and the degradation of the environment. It is becoming more difficult to satisfy the ever-increasing global demand for animal protein as land availability and resources are declining. The production of mini-livestock can be a possible solution to solve this dilemma. Although humans have evolved as an insect consuming species, the consumption of insects has dramatically decreased since the introduction of religions some 2000 years ago. However, more than 2,000 species of insects are still being consumed in more than 88 countries across the world. The farming of insects provides various benefits over conventional livestock farming, i.e. the higher diversity of the insect kingdom, its rapid reproduction rate, its high nutritional value, its energy efficiency and to produce insects is cleaner. Insects can be regarded as a more safe and nutritional food source compared to conventional sources such as eggs, milk, nuts and soya. Humans can drastically decrease their carbon footprint and impacts on the environment if more people can start consuming insects rather than conventional livestock products.

However, one should remember that although the production of mini-livestock holds much promise, implementing it may result in challenges and uncertainties not known as of yet. For any meat alternative to be successful, it must be accepted by the consumer. With the current limited set of quantitative data available, it may appear that to solve these challenges may not prove to be too difficult.

Chapter 6: Survey results

6.1 Survey overview

Over the last decade or two, consumers have become more aware of what they eat and where it comes from. The impact of producing and consuming specific food products on personal health, animal welfare and the environment are being questioned by consumers in an effort to contribute to a more humane and sustainable way of life. There is a general perception that this more conscious way of living has promoted organic farming practices, vegetarianism, veganism and pescatarians.

To substantiate the perception that there is indeed a higher level of consciousness around the food chain and that this drives the changing behaviour, a short survey was conducted with a sampling size of 1450 people. The survey (see Annexure B) was sent to the Stellenbosch University students, Alumni and staff members via email and was active for seven days (03 December 2019 – 10 December 2019). The survey was constructed out of closed questions to evaluate how informed the public is on the environmental impact of the livestock industry, their meat preferences and their willingness to explore alternative protein sources.

The responses and correlations between variables will be examined and discussed in this chapter.

6.2 Results and discussion

The first question of the survey was focussed on determining the age of the sample audience. It is evident from the survey results that the majority of the participants (over 50%) are between the ages of 18 and 25 (refer to Figure 6.1). It is thus clear that the majority of the participants are young students; a group one will presume is more open to experimentation and new ideas.

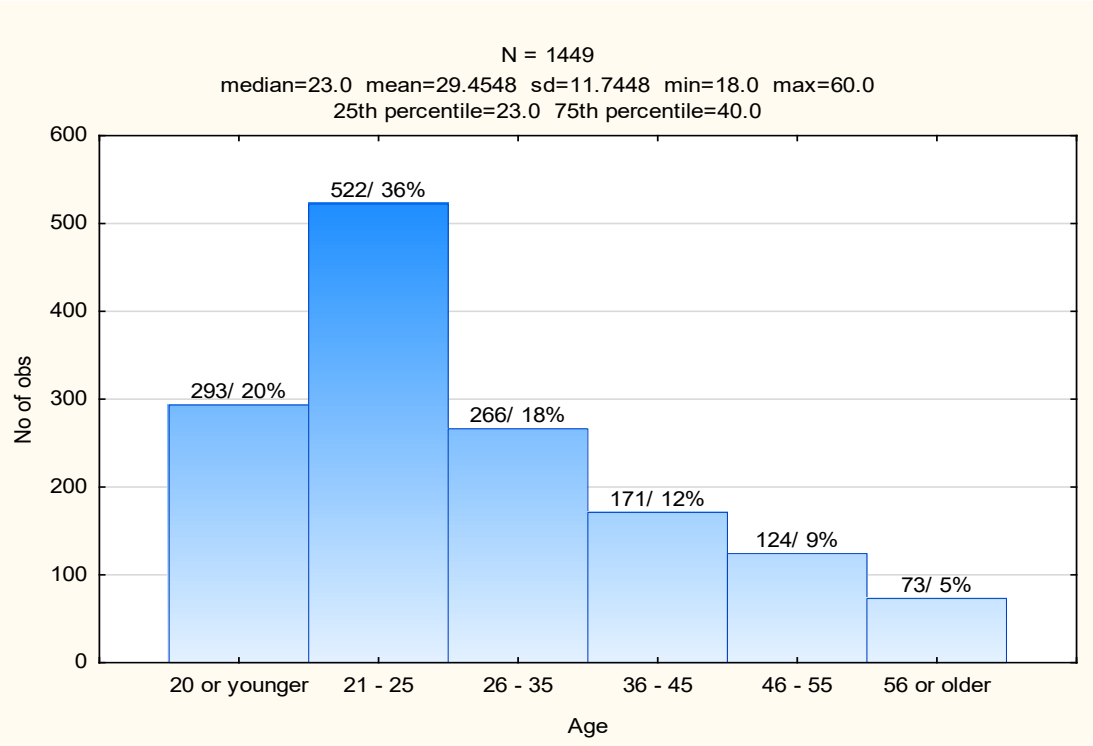

Figure 6.1 - Age distribution of survey participants.

The second question determined the average income per month of the participants.

It was predicted that most of the participants would be students and thus the majority of the participants would fall in the lowest income bracket. The results confirmed this indicating the income per month bracket of R0 – R10,000 as the most common group accounting for 59%, with R20,001 – R30,000 second with 10%, and R10,001 – R20,000 third with 9% (refer to Figure 6.2).

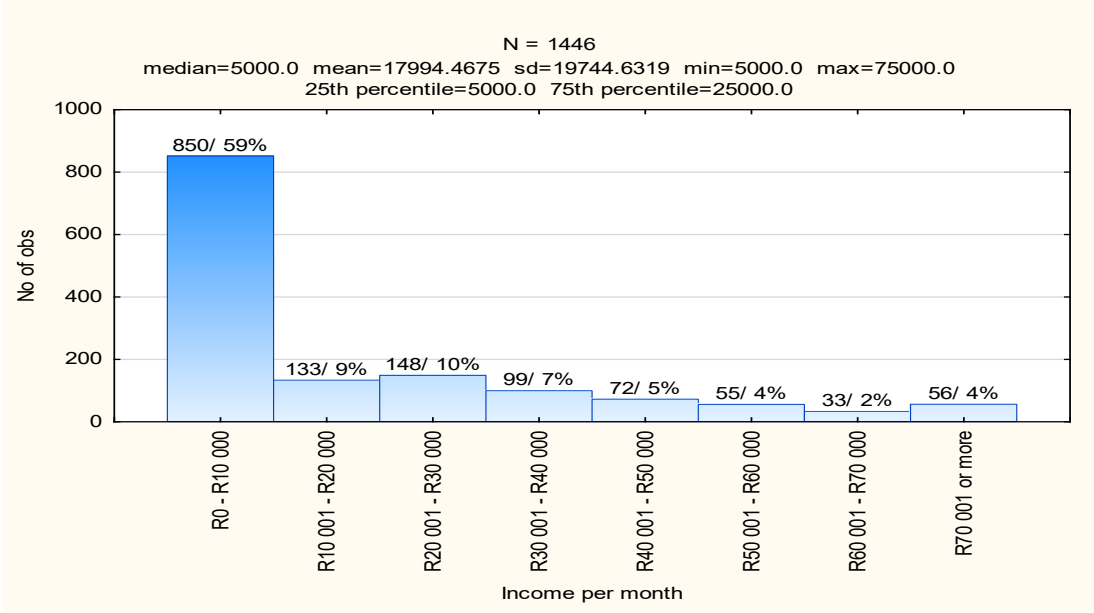

Figure 6.2 - Income per month of survey participants.

Figure 6.3 shows how many participants do eat meat. Although there is a growing vegetarian movement around the world, it was expected that the majority of participants would be meat eaters. The results of the survey supported this by indicating that 93% of participants eat meat (refer to Figure 6.3).

A follow up question was asked to determine why the participants do not eat meat.

The participants who don't eat meat is mainly due to them being vegetarian. The second reason being pescatarian and the third, vegan (refer to Figure 6.4). The survey could have been more specific by providing alternative reasons such as religious, health or animal welfare reasons for not eating meat. Different people have their own personal reasons for not eating or eating meat, but this survey was designed to obtain a basic overview of the general public's preferences.

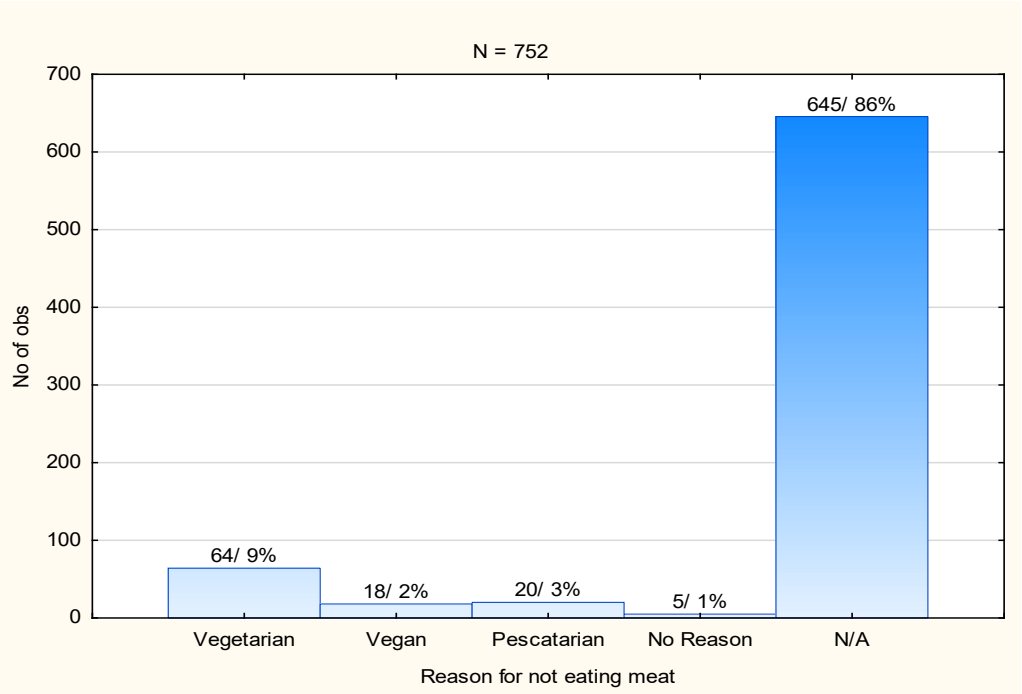

Figure 6.3 - Survey participants eating meat or not.

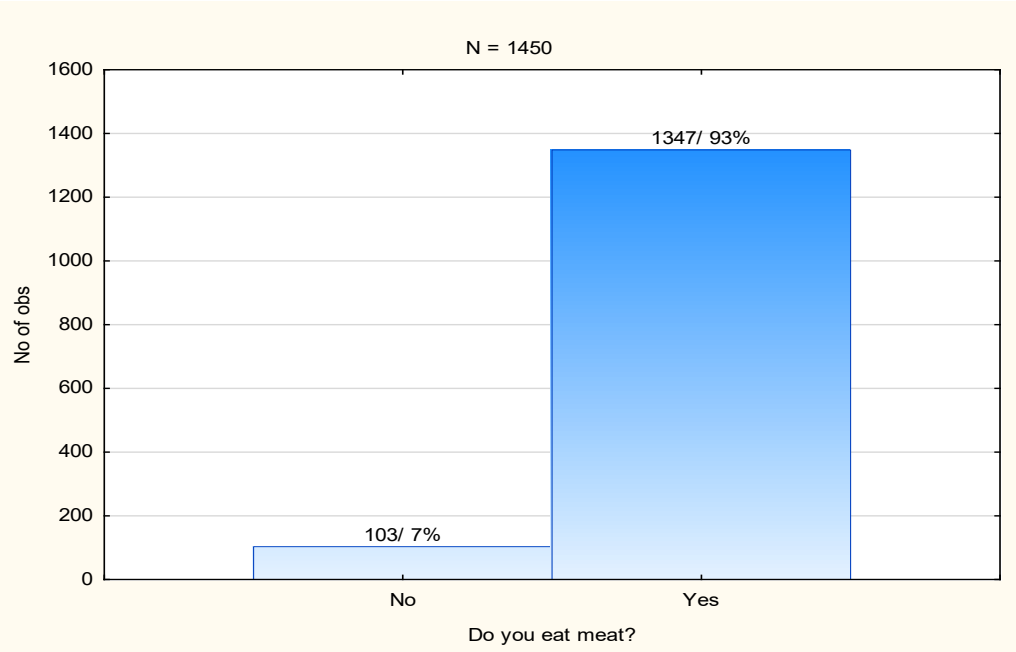

Figure 6.4 - Reason for not eating meat.

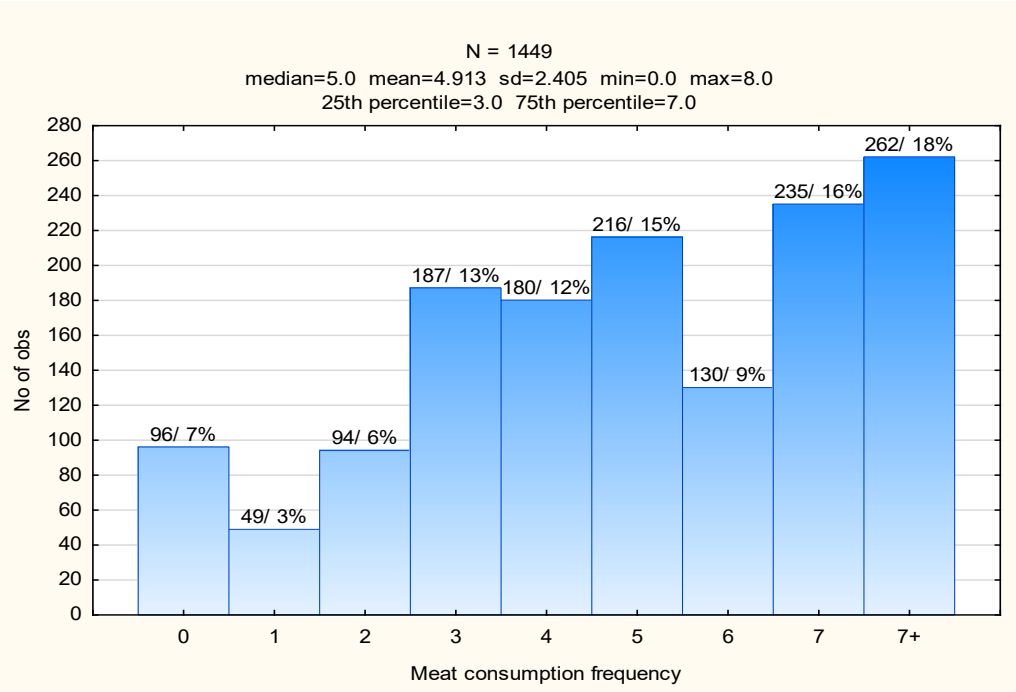

Figure 6.5 - Participant's meat consumption frequency.

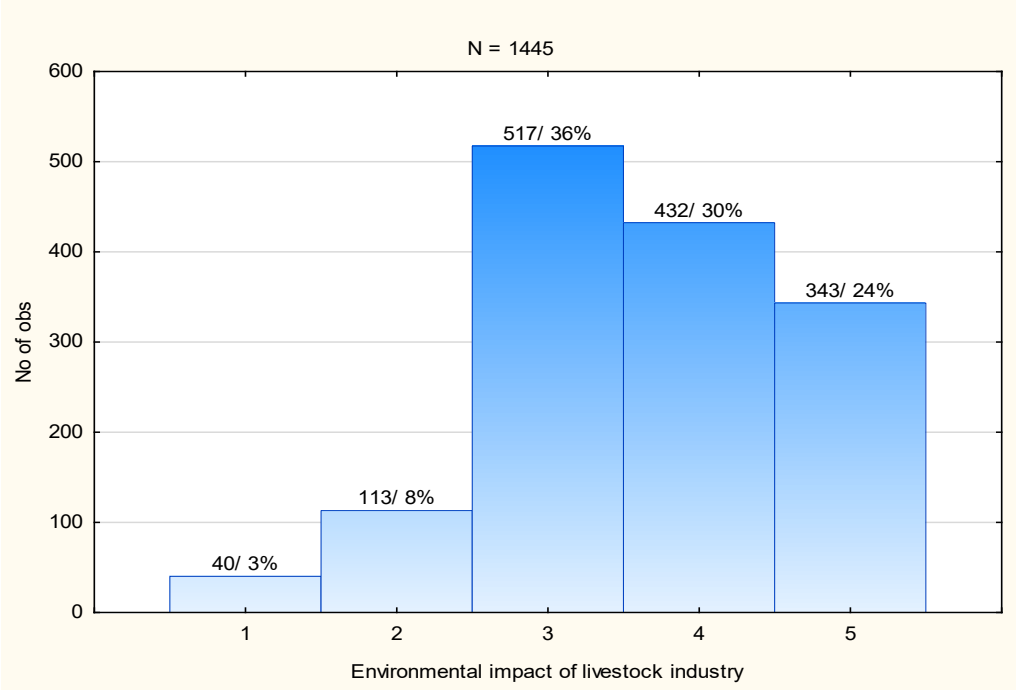

Figure 6.6 - Environmental impact of the livestock industry according to the participants.

A question was asked to determine how frequent participants eat meat per week. From the 93% of meat eaters, most participants consume meat more than five times a week (refer to Figure 6.5). Most participants (18%) consume meat more than 7 times a week, with the second largest group being 7 times a week (16%) and the third largest group being 5 times a week (15%) (refer to Figure 6.5). This indicates that meat forms part of the average participant's diet almost on a daily basis.

To determine how the average participant rates the environmental impact of the livestock industry, a Likert scale was used with 1 being little and 5 being highly degrading. The survey proved that the majority of the participants understand that the livestock industry has a negative impact on the environment. The largest group (36%) rates the environmental impact as a 3/5, the second largest group (30%) as a 4/5 and the third largest group (24%) as 5/5 (refer to Figure 6.6). It is quite ironic that despite the knowledge the participants have on the environmental damages caused by the livestock industry, the vast majority eat meat quite frequently, if not on a daily basis. This can be because of a number of reasons. Either they don't truly understand the environmental impact of the industry, are too lazy/close-minded

to change diets, too used to eating meat, too stubborn to change diets, scared of what others may think or couldn't care less about the environmental impact.

It is interesting to note that although most of the participants understand the livestock industry's environmental impact, the majority (55%) believes that the transport industry is responsible for more greenhouse gas emissions than the livestock industry (refer to Figure 6.7). As mentioned in Chapter 3, the livestock industry is responsible for far more greenhouse gas emissions than the entire transport sector combined. It emits about 35% to 40% of global anthropogenic methane, 9% of carbon dioxide and 65% of the global anthropogenic nitrous oxide emissions (Abbasi and Abbasi, 2016).

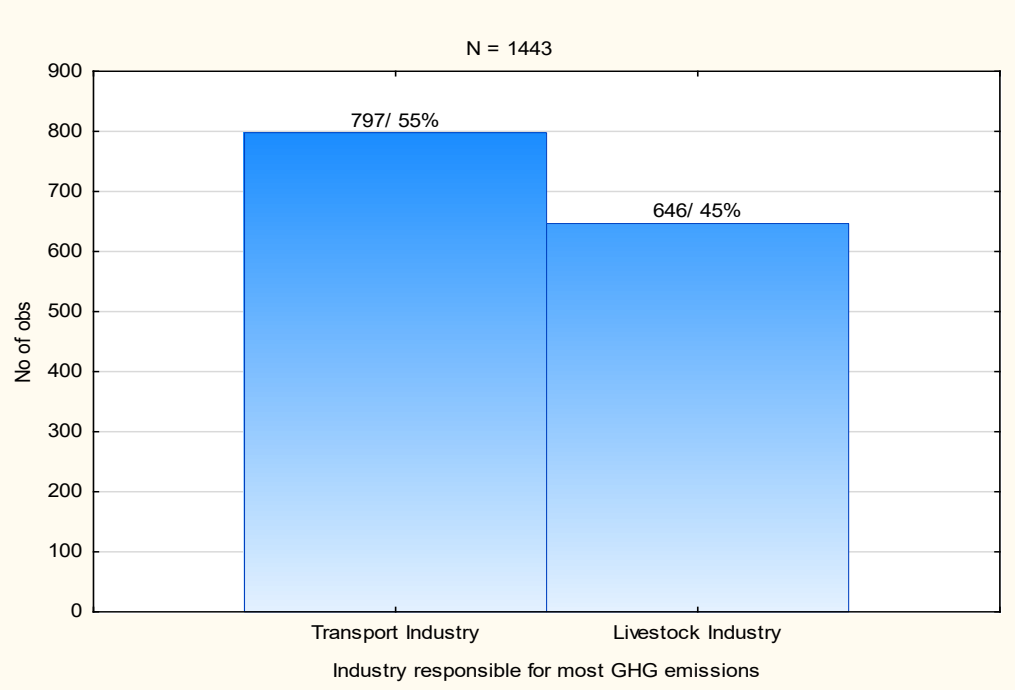

Figure 6.7 – Industry responsible for emitting the most greenhouse gas emissions.

It was assumed that the majority of people would be unaware of how much water is required to produce meat products. The survey thus posed a basic question to see how aware the participants are on the water usage that 1kg of beef requires. Most participants (52%) believed that it requires between 10,000 to 20,000 litres of water, with 39% saying between 100 to 1,000 litres and 9% thinking between 35,000 – 45,000 litres (refer to Figure 6.8). It is estimated that to produce 1kg of beef requires about 43,000 litres of water, as mentioned in Chapter 3 (Pimentel, 1997). A follow-up question was asked to see how the participants think

they can save the most water. The result was that 59% of participants believe reducing domestic water usage was the best way to save water, with 37% saying a change to a meat-free diet is the best way and 4% believing to buy less bottled water (refer to Figure 6.9). It is known that globally only 10% of the world's freshwater is used domestically while the agricultural industry consumes 70% (Henning, 2011).

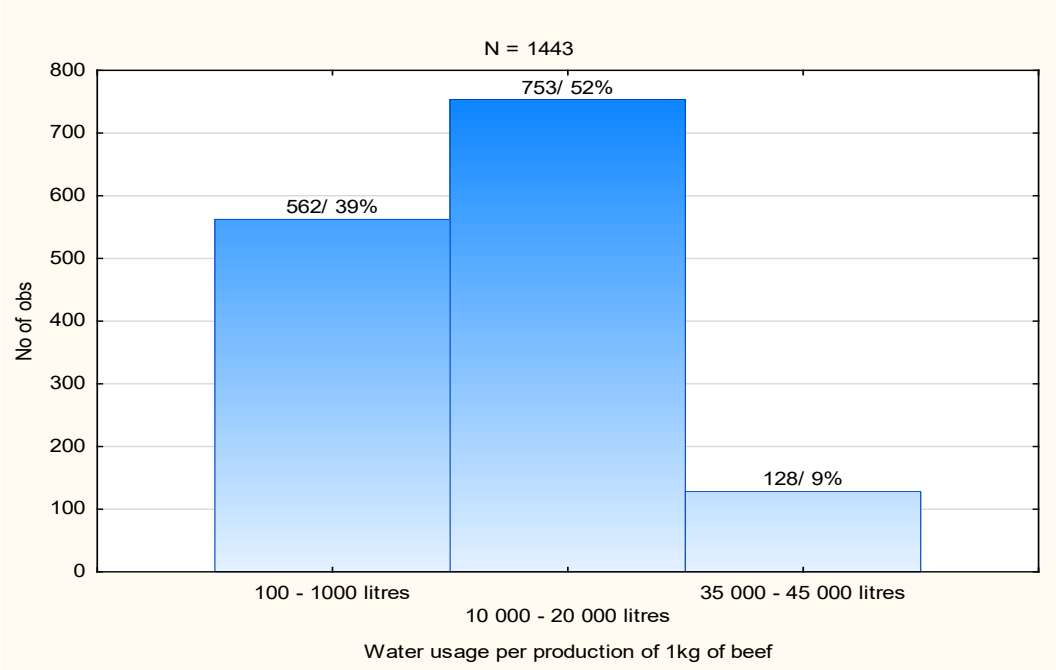

Figure 6.8 - Participants' perception on water requirements to produce 1kg of beef.

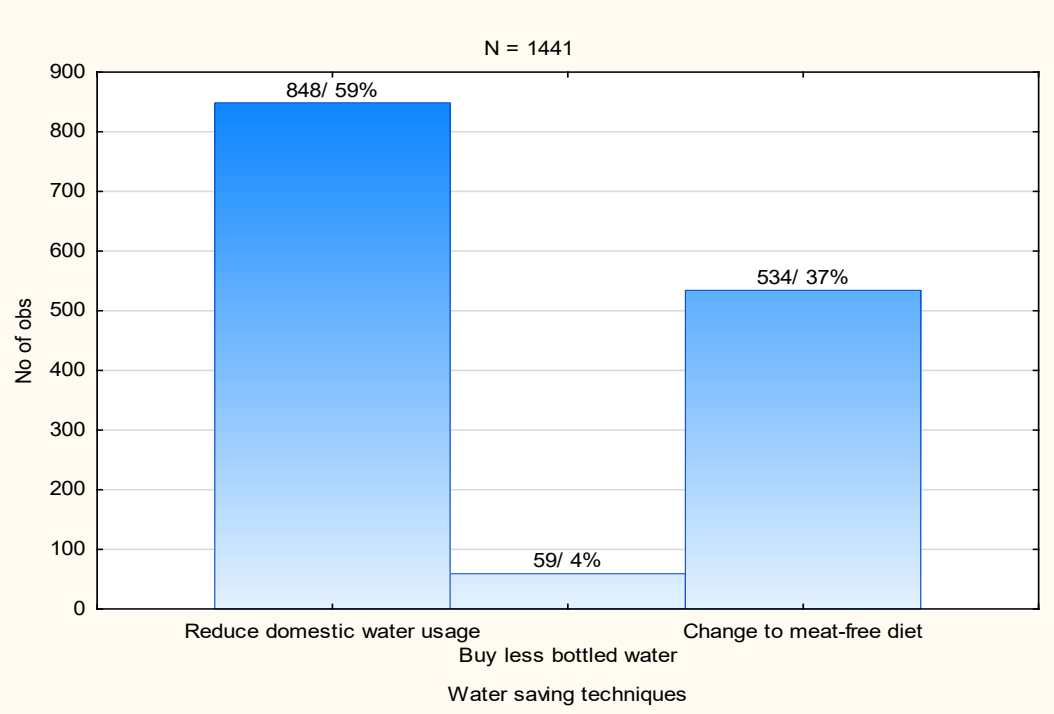

Figure 6.9 - Best way to reduce water usage according to the participants.

The participants were asked whether or not they implement some sort of domestic water saving technique. The survey proved that 91% of participants do implement some sort of domestic water saving technique (refer to Figure 6.10). It can thus be concluded from the survey that the majority of participants understand the high-water usage associated with beef production and implement water saving techniques at home, but still consume meat regularly.

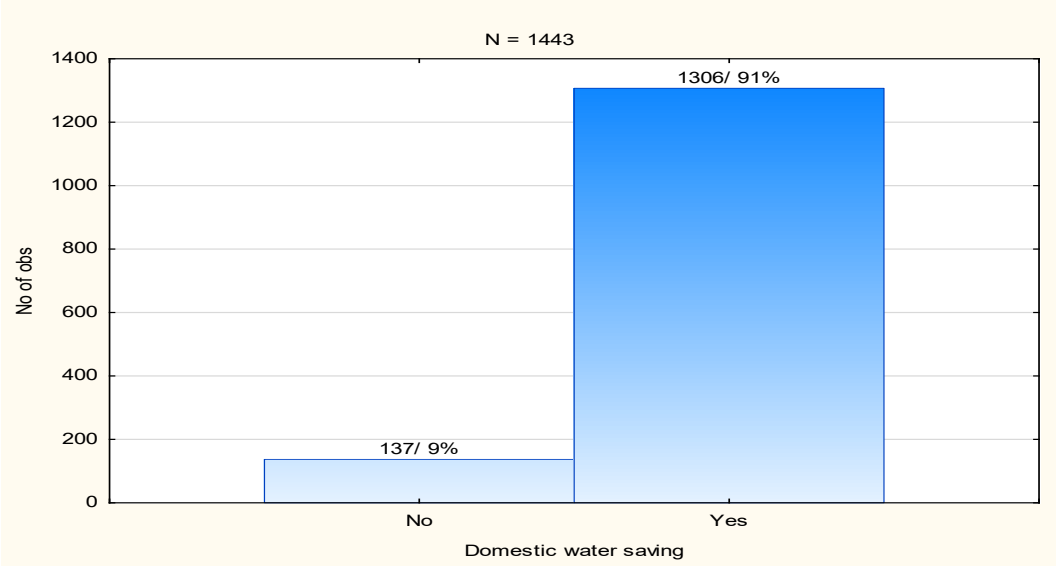

Figure 6.10 - Domestic water-saving techniques implemented by participants.

It is interesting to note that the majority of participants (59%) believe that reducing domestic water usage is a better method to save water than the 37% of participants who believe it is changing to a meat-free diet. This may be because of the fact that water awareness programmes were launched in South Africa, which were solely focused on saving water domestically. Thousands of posters were erected to make people aware not to leave a tap running or to rather wash a car with a bucket of water, when the biggest water consumer, the livestock industry, was never even mentioned. It is obviously unrealistic to expect that an entire country should change their diets to being vegetarians, but the water awareness programmes should have included posters on reducing meat consumption. Some people may have been confused at first, but that is how a conversation or research into the matter starts. One person becoming vegetarian will not have an impact on the demand and thus influence production of meat products, but a large group of people will decrease the demand below a

certain threshold, which will result in a decrease in production and thus result in less water being used. One can only speculate that if the public was fully informed of the livestock industry's high water demand, and water awareness programmes included posters on reducing meat consumption, whether the survey's results would have shown a lower frequency of consuming meat and even the a smaller number of people who eat meat.

It was expected that the majority of participants would not have consumed insects before. A question was asked to confirm this, which was supported by the survey as 87% of participants have never eaten processed insects before (refer to Figure 6.11). A follow-up question was asked to understand why participants would not consider eating insects. The participants were mainly (52%) grossed out by insects, with 28% opting for "other" reasons and 15% choosing taste (refer to Figure 6.12). It is quite ironic as most insect species are much cleaner than other animals; humans (93% of participants) tend to consume without hesitation (Premalatha *et al.,* 2011). Unfortunately, as mentioned in Chapter 5, organized religions and globalization started having an impact on how humans perceive insects. The consumption of insects started to decrease and was viewed as a disgusting food source for humans to consume. This is unfortunate as insect-farming is more sustainable compared to conventional macro-livestock. It requires less space, less energy, less water and produces the same quality, if not better, animal protein for humans (Premalatha *et al.,* 2011).

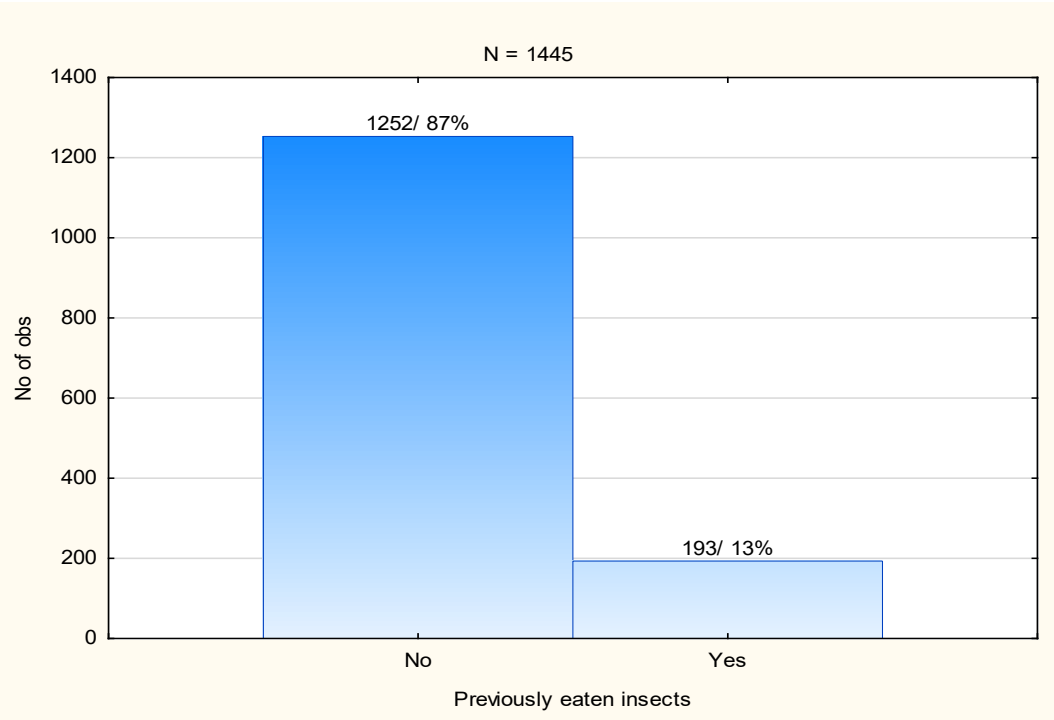

Figure 6.11 - Participants that have eaten processed insects.

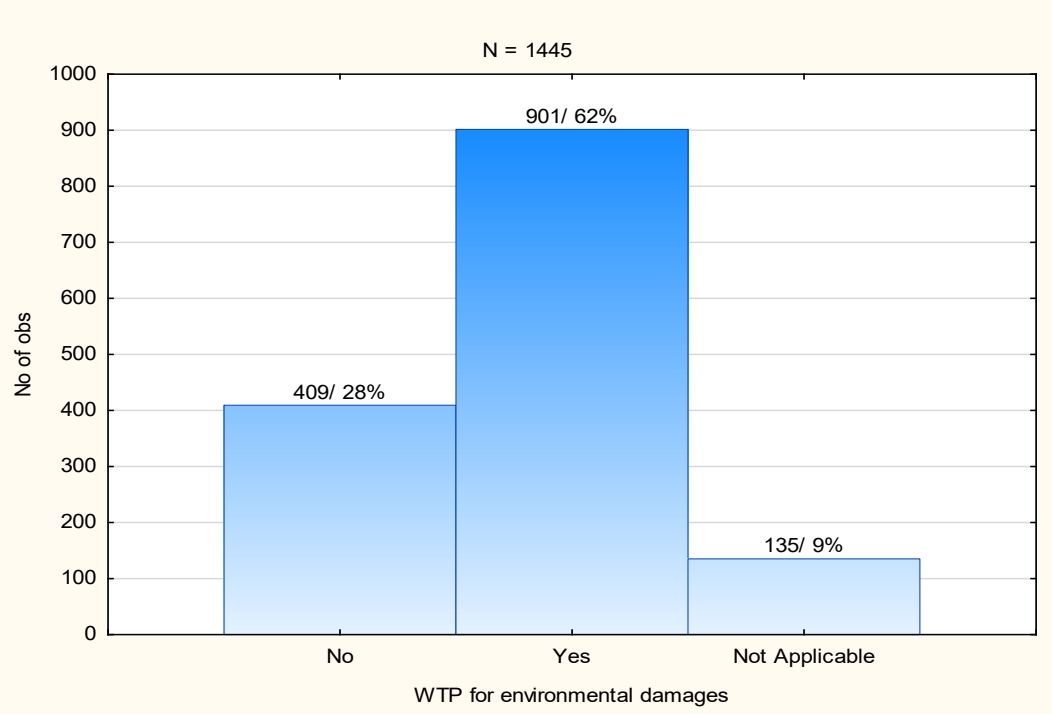

Figure 6.12 - Reasons for participants not eating insects.

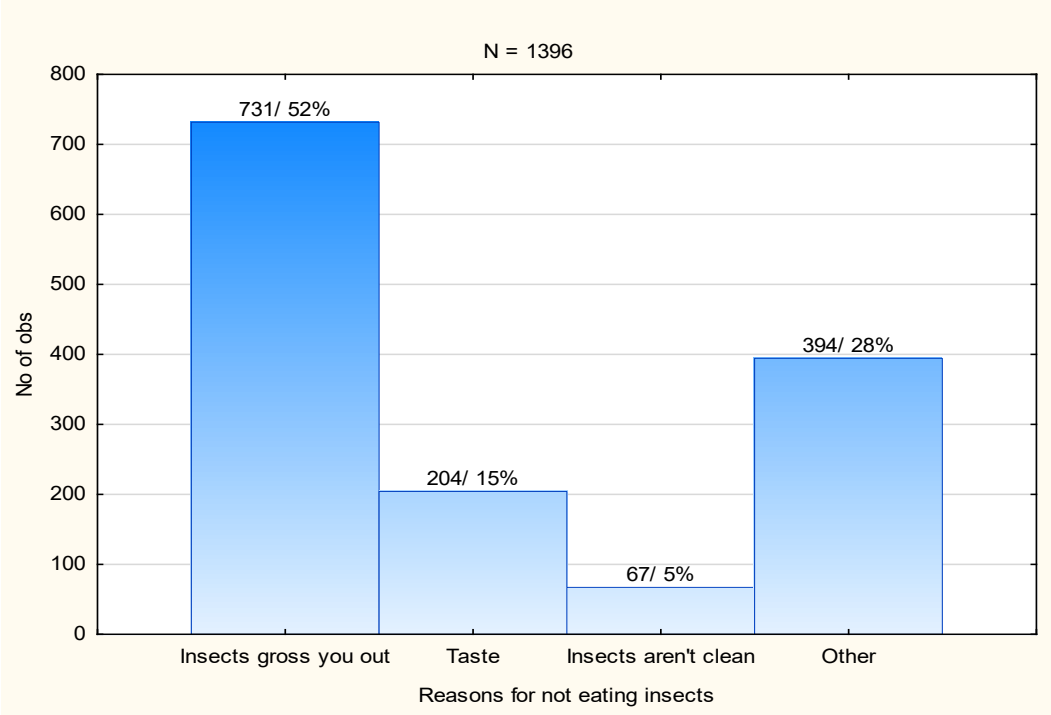

Figure 6.13 – Participants' willingness to pay more for meat to address environmental damages caused.

A question was asked to test whether the participants would be willing to pay more for their meat products, with the extra charge going towards addressing the environmental impacts caused by the production process. The survey indicates that 62% of meat eaters are willing to

pay more for meat if the increase in price goes towards addressing the environmental impact caused by producing meat products (refer to Figure 6.13). A follow-up question was asked to determine how much people are willing to pay more for meat products. The majority of them are willing to pay anything between R2/kg to R10/kg more with the minority willing to spend more than R20/kg, or more, to address environmental damages (refer to Figure 6.14). This indicates that the general consumer feels at least some responsibility for the impacts of her/his lifestyles. It shouldn't solely be the consumer's responsibility to pay for the external costs associated with producing meat, but also the producers. Policy makers should put their heads together to formulate a plan that will address the external costs created by the livestock industry and make both the producers and consumers responsible for their behaviour.

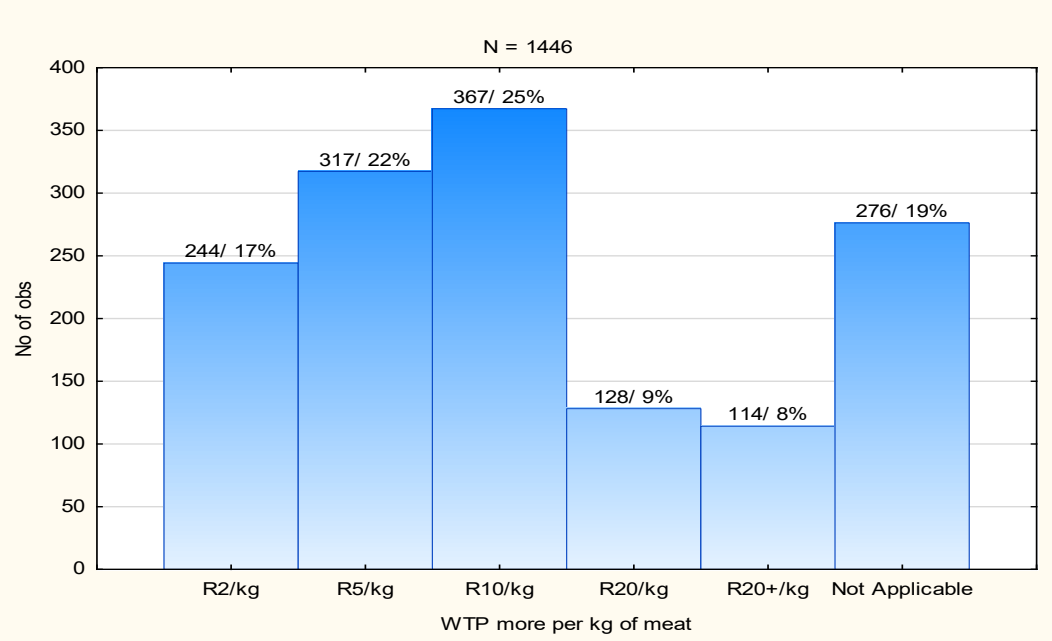

Figure 6.14 - How much participants are willing to pay more for meat to address environmental damages caused by producing the product.

Statistical analyses were performed to determine whether age is related to eating meat or not. The null hypothesis was that there is no relationship between age and whether or not a person consumes meat. It is generally assumed that the younger generations are more aware of environmental problems than older generations, meaning that age would impact the person's choice of consuming meat or not. The statistical analysis (F-test) proved that there is a relationship between age and eating meat, with the p-value being smaller than 0,05 (refer to Figure 1 in Annexure A). However, because the sample size of the survey was large, a Cohen's D – test was performed to calculate the practical difference between the two variables, which was found to be rather insignificant (refer to Table 1 in Annexure A). It can thus be said that age did not influence the survey audience's choice of eating meat or not. This is also supported by Figures 6.1 and 6.3 that indicate the majority of the audience is young and eats meat.

The variable of age was again tested to see if there is a correlation between age and the quantity of meat the person consumes per week. This was calculated using the Pearson Correlation Coefficient (PCC) test. The result of the Pearson value was -0.07, which means that there is a weak negative correlation between the two variables. The p-value for the PCC test resulted in 0.01, which means that there is a relationship between the two variables (refer to Table 2 in Annexure A). The correlation between income per month and whether a person eats meat or not, was also calculated by a PCC test, which resulted in a Pearson value of 0 (refer to Table 2 in Annexure A). This means that there is no correlation between the two variables – this was further supported by the p-value of 0,9, which indicates that there is no relationship between the variables (refer to Table 2 in Annexure A). A PCC test was also conducted to test whether there is a correlation between income per month and willingness to adopt insect-based products instead of meat products. The test resulted in a Pearson value of 0.08, which indicates a weak positive correlation (refer to table 2 in Annexure A). The p-value was smaller than 0.01, which further indicates that there is a relationship between the two variables (refer to Table 2 in Annexure A).

It was of interest to test whether income per month would influence the person's willingness to pay more for meat if the excess money goes towards addressing the environmental damages caused by producing meat. The null hypothesis is that there is no relationship

between the two variables. After the F-test was performed a p-value of 0.49 suggests that there is no relationship between the two variables (refer to Figure 2 in Annexure A). However, once again, because of the large data group, a Cohen's D-test was performed, which proved that there is no real significant relationship between the variables (refer to Table 3 in Annexure A). Thus, it can be said that income per month did not impact the participants' willingness to pay more for meat products to address the environmental damages caused by the production of the meat.

A F-test was used to determine whether there is a relationship between age and which water saving technique the person thinks is the most efficient to save water. This was done to see whether older or younger people are aware that the most effective way would be to change to a meat-free diet. The F-test resulted in a p-value that was smaller than 0.01, which suggests that there is a relationship between the variables (refer to Figure 3 in Annexure 1). Because there are three variables within this comparison, Fisher's Least Significant Difference test was conducted (refer to Table 4 in Annexure 1). Although some relationships were proposed by the test, a Cohen's D test was conducted due to the large sample group (refer to Table 5 in Annexure 1). This concluded that there are no practical significant relationships between the variables, which means that age did not impact the participant's knowledge as to know which method is the best to save water. This just further emphasizes the fact that the majority of people were brought under the impression by the government and municipalities of South Africa, that the best way to save water is to reduce one's domestic usage. It is quite frightening that people can be so easily "controlled" or "educated" regarding a problem that they will believe what is portrayed by the authorities. This may not be the only reason why the participants think the way they do, but it is a most plausible theory given the circumstances in which the country finds itself in terms of drought.

6.3 Conclusion

It is evident from the survey that the majority of participants (being young and in a low-income bracket) are mostly meat eaters. It is safe to say that the majority of participants are aware of the environmental impact the livestock industry has, but still chooses to consume meat. The reasons for still consuming meat are unknown, and may be an interesting subject

to further investigate. It is also evident that the majority of participants are implementing some sort of basic water saving technique at their homes to help save water during a drought. Most participants are of the opinion that by reducing domestic water usage, they can save more water than by switching to a meat-free diet. It is speculated that this may be due to water awareness programmes in South Africa being purely focused on domestic water usage without paying any attention to other important factors such as one's diet. This is merely speculation and it could be interesting to do a more thorough investigation into understanding the general public's knowledge regarding the livestock industry and saving water. It was found that age did not significantly impact the audience's choice of eating meat or their knowledge of the environmental impact of the livestock industry. The data can be improved by incorporating older participants as this survey's audience was fairly young, and by obtaining information from an audience that is more widely distributed. Most of the participants are more than willing to take responsibility for their actions and pay more for meat products to address the environmental damages caused by the production process, with most of them being part of to the low-income bracket. This proves that money does not impact their choice of eating meat or wanting to help combat environmental issues.

The survey could be improved by providing more options to support people who have different reasons for eating meat, or not, than the ones provided. No accommodation was made for people's religious or health reasons for not consuming meat. Moreover, some people may consume meat of animals only raised by themselves or in areas of which the conditions are known. Thus, it can prove insightful to make the survey as accommodating as possible and to provide more open-ended questions with some freedom of answering. It would also be interesting to know the differences between gender when it comes to meat consumption and environmental stewardship. The setup of the survey was done in a very basic manner to obtain a better understanding of where the general public's standpoint is.

It is safe to say that the question of whether a person eats meat or not, is not as simple as "yes" or "no," but requires an in-depth understanding of the different ways people live. However, with that being said, this survey did provide a very basic understanding of what the general public's position is regarding meat consumption and environmental issues associated with it, as well as their knowledge on the livestock industry. It seems as if educational

programmes focusing on the livestock industry will not only help the public be more aware of the issue, but may also have a positive impact on the environment. Such programmes on the livestock industry can be complemented by educational programmes on the alternatives to meat in order for the public to make informed decisions on how to obtain the necessary protein required to function optimally.

Chapter 7: Conclusion

The thesis highlights the interdisciplinary nature of the 'meat-debate'. The socio-economic, environmental and ethical aspects are investigated in an attempt to dissect this ever growing debate and bring forward realistic solutions/recommendations.

It is clear that South Africa's livestock industry plays a vital economic role in the country. It provides employment opportunities, food, products, money and develops the country's workforce. In rural areas, livestock is seen as a form of wealth, which can be utilised at any time by the owner for whatever purpose. Livestock is thus deeply rooted in South African culture. However, with the growing human population and demand for meat products, the toll it takes on the environment and animals is becoming a serious matter. The quality of the country's water, air, soil, wildlife, as well as human health, is virtually under siege. In a water scarce country such as South Africa, where every drop of water needs to be saved, it is vital that a conversation is started on how much water the livestock industry consumes. Large quantities of water can be saved when a large population changes its dietary lifestyles. Domestic water saving techniques are a good start, but more drastic measures need to be taken, especially in an area that is predicted to become drier and warmer due to climate change. Due to the high demand for meat, mass production operations often neglect the animals, which results in animals enduring horrendous living conditions and sometimes inhumane deaths. Apart from the fact that the animals suffer, the general public usually pays for all the negative environmental impacts associated with the livestock industry through the environment being heavily degraded.

Educational programmes on environmental damages caused by the livestock industry, as well as alternative protein sources need to be implemented to educate the public on the topic. The human consumption of insects is a most attractive alternative to the more conventional production of macrolivestock. The stigma associated with eating insects must be eradicated – this will open endless opportunities of more sustainable livelihoods. When the public has sufficient knowledge of how destructive the livestock industry is, only then can they make informed decisions on whether or not they wish to consume meat. Moreover, the South African government needs to implement policies to hold producers and consumers

responsible for their lifestyle choices. The price of meat needs to incorporate a tax that should be used to address the external costs associated with the industry. Moreover, the increase in price will hopefully decrease the demand for meat and thus reduce the industry's impact on the environment. Alternatively, the government can create incentives for livestock farmers to farm in a more sustainable manner, which would make the productivity of their livestock more efficient, whilst decreasing the impact on the environment. Alternative farming practices should be investigated and can be adopted by the livestock industry.

To better understand human behaviour and what makes meat so attractive to most, an in-depth survey should be done. Whether a person eats meat or not is not as simple as a "yes" or "no" answer, but is influenced on so many different levels. Once the psyche of humans is understood, only then will it become clear why humans are so attracted to eating animals.

It cannot be expected that the livestock industry be eradicated overnight, but educational programmes and certain policies should be implemented to provide the general public with the necessary information to make informed decisions. If the government does not intervene, South Africa, and the whole world for that matter, will soon face an environment degraded to such an extent that future generations will have no means to sustain their livelihoods.

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Annexure A

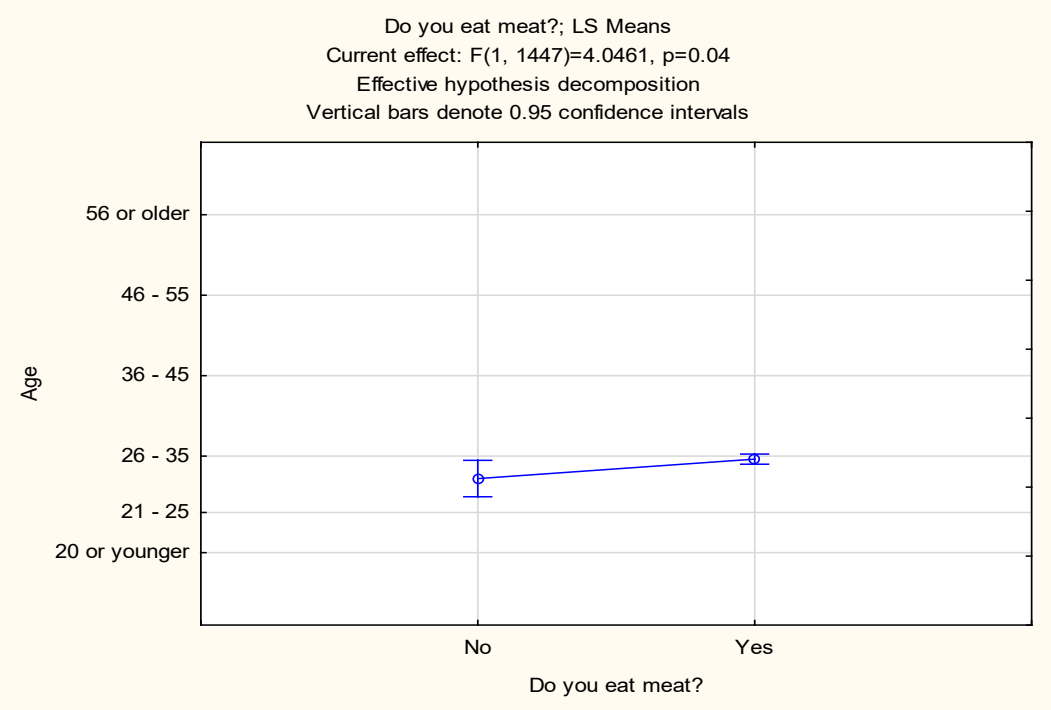

Figure 1 - Age vs eating meat or not.

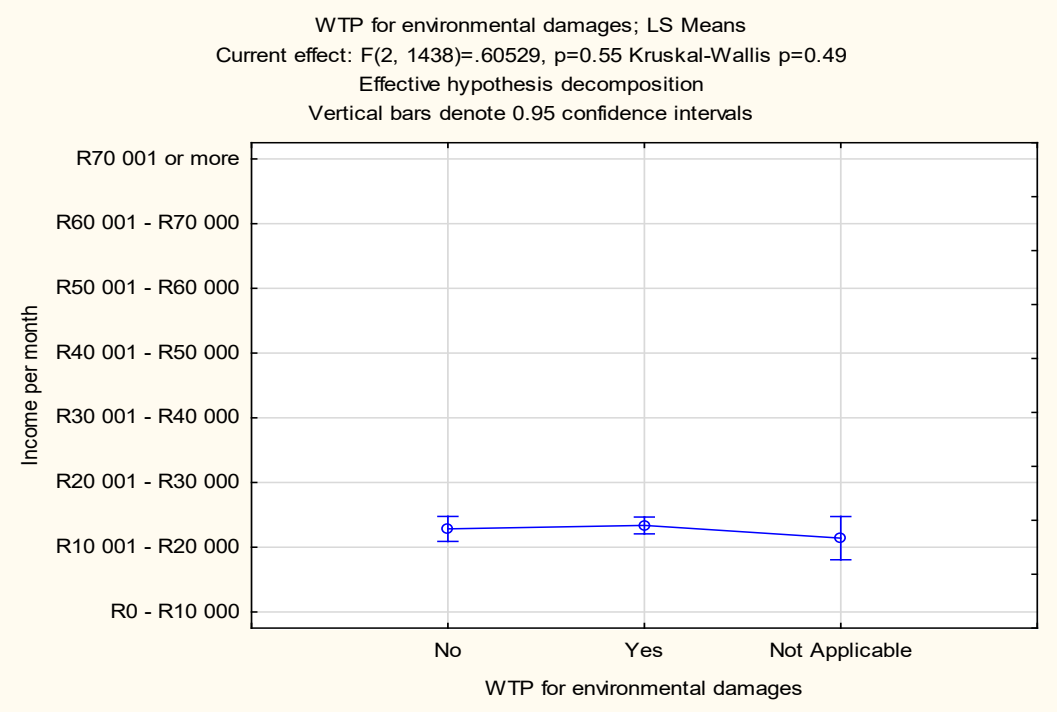

Figure 2 – Income per month vs. willingness to pay more money for meat to address environmental damages.

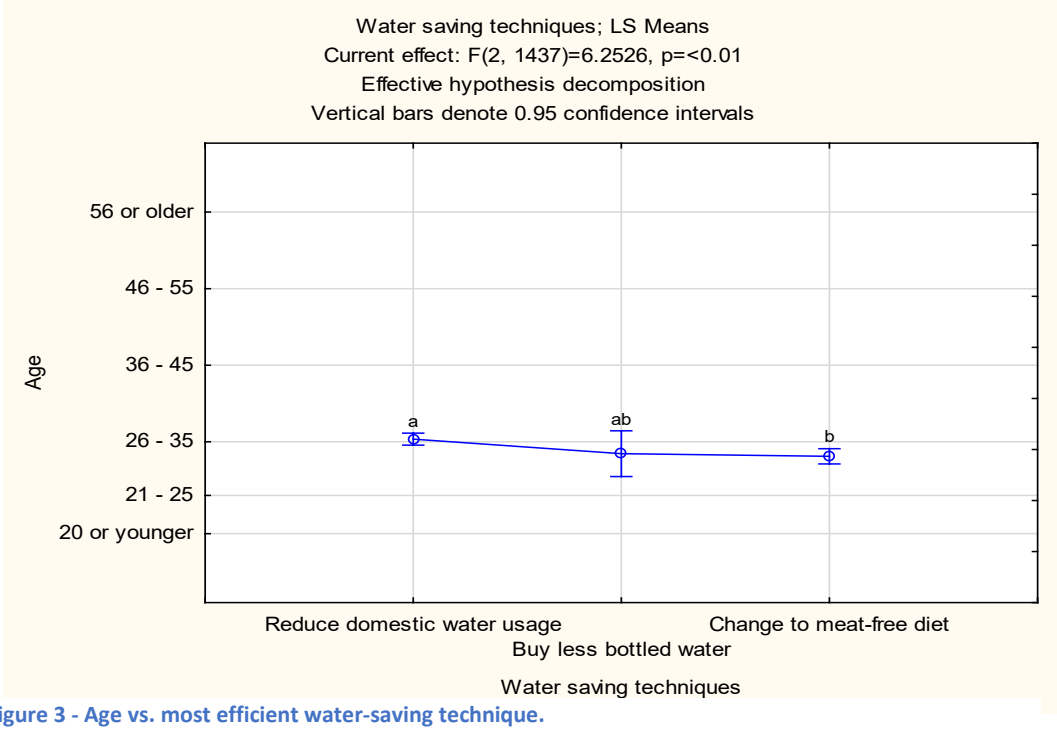

Figure 3 - Age vs. most efficient water-saving technique.

Figure 3 - Age vs. most efficient water-saving technique.

Table 1 - Cohen's D test for age vs. eating meat or not.

	Do you eat meat?	{1}	{2}
1	No		0.21(small)
2	Yes	0.21(small)	

Table 2 - Correlations between variables.

	Perception.on.the.meat.industry_spss in resultate						
	variable 1	variable 2	Pearson	Pearson p-val	Spearman	Spearman p-val	# cases
1	Income per month	Meat consumption frequency	0	0,9	-0,03	0,3	1445
2	Age	Meat consumption frequency	-0,07	0,01	-0,08	<0.01	1448
3	Income per month	WTP more per kg of meat	0,08	<0.01	0,05	0,04	1442

Table 3 – Cohen's D - test for willingness to pay more vs income per month.

	WTP for environmental damages	{1}	{2}	{3}
1	No		0.03(negligible)	0.07(negligible)
2	Yes	0.03(negligible)		0.1(negligible)
3	Not Applicable	0.07(negligible)	0.1(negligible)	

Table 4 - Fisher's Least Significant Difference test between variables.

Cell No.	LSD test; variable Age (Perception.on.the.meat.industry_spss in resultate) Probabilities for Post Hoc			
	Water saving techniques	{1} 30.351	{2} 28.458	{3} 28.107
1	Reduce domestic water usage		0.229043	0.000528
2	Buy less bottled water	0.229043		0.826941
3	Change to meat-free diet	0.000528	0.826941	

Table 5 – Cohen's D test between variables

	Water saving techniques	{1}	{2}	{3}
1	Reduce domestic water usage		0.16(small)	0.19(small)
2	Buy less bottled water	0.16(small)		0.03(negligible)
3	Change to meat-free diet	0.19(small)	0.03(negligible)	

Annexure B

1. Age?
2. Gross income per month: (0-1000; 1000-5000; 5000-15000; 15000-25000; 25000+).
3. Do you eat meat (yes/no); If no why? (Vegetarian, vegan, pescatarian, no reason).
4. How many times per week do you eat meat? (0/1/2/3/4/5/6/7+/occasionally/not every week).
5. On a scale of 1-5 rate the environmental impact of the livestock industry (5 being the most).
6. Which industry do you think produce the most Greenhouse gas emissions? (Transport or livestock sector?).
7. How many litres of water do you think it takes to produce 1kg of beef (100-1000l/10000-20000l/35000-45000l).
8. Which method do you think is the best way to save water (Reduce domestic water usage/ buy less bottled water/ change to meat-free diet)?
9. Do you implement any basic water saving techniques at home? (Yes/No).
10. On a scale of 1-5 how open are you to consider replacing meat with insect-based protein products?
11. Have you eaten processed insects before? (yes/no).
12. What is the reason you won't eat insects? (1. Insects gross you out, 2. Taste, 3. Insects are not clean, 4. Other).
13. Would you be willing to pay more for meat, if the increase in price was to address the environmental damage caused by the process of producing meat? (Yes/No).
14. How much more would you be willing to pay per kg meat if you knew that the extra charge went to address environmental damages caused by meat production? (R2/R5/R10/R20/R20+).